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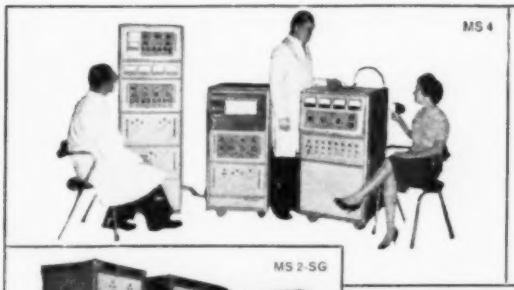

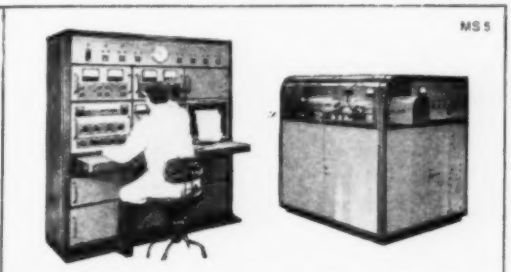

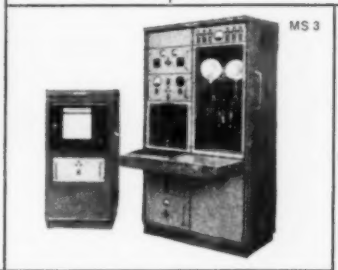

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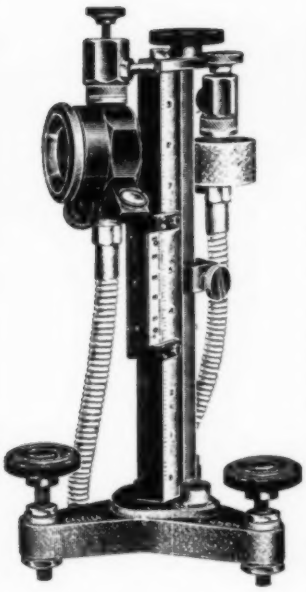

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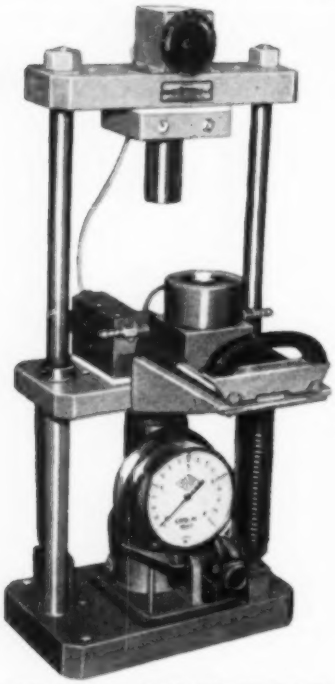

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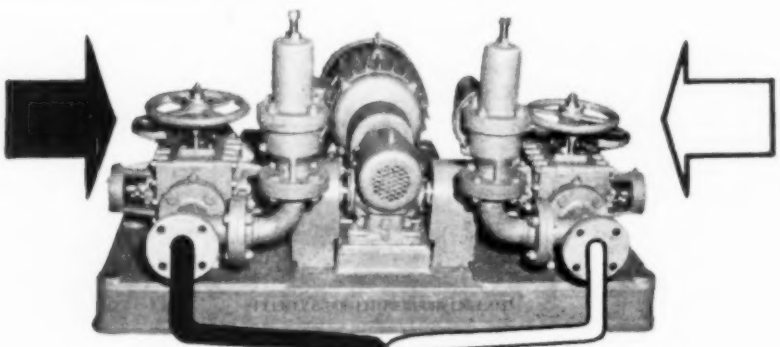

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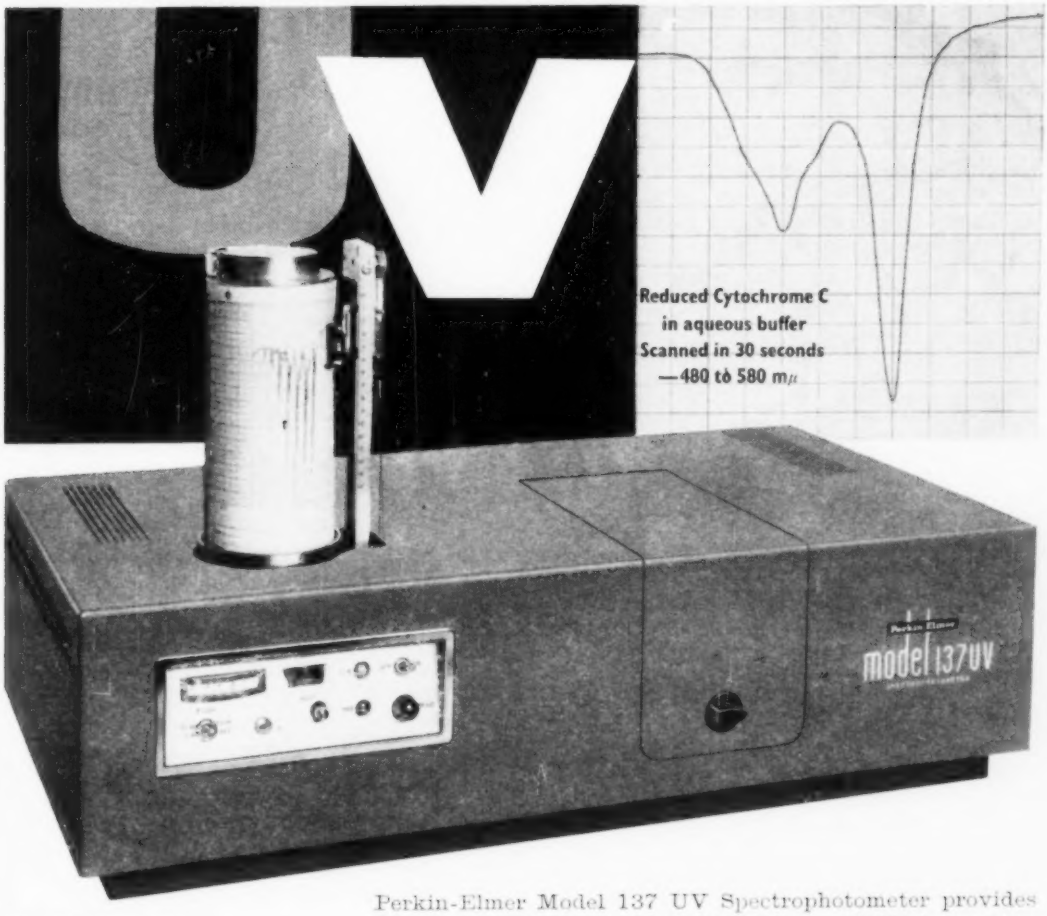

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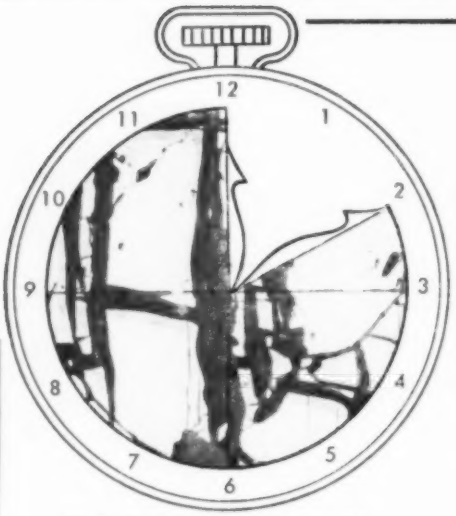

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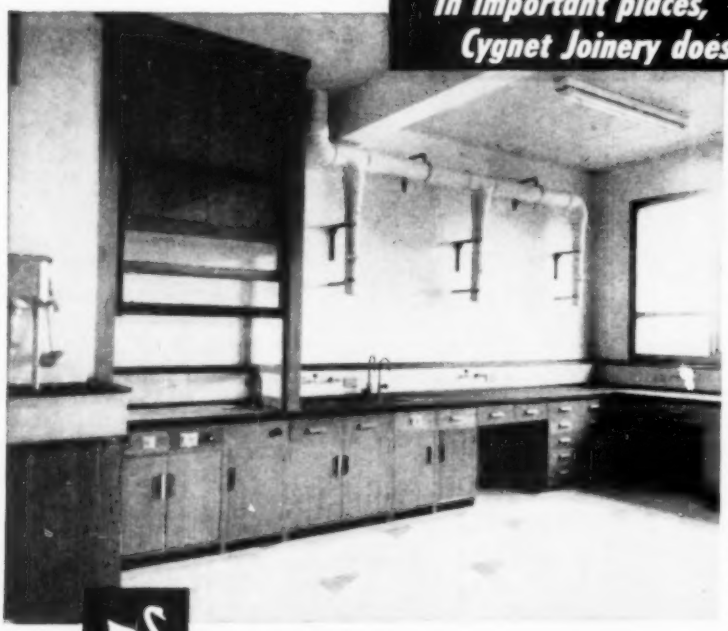

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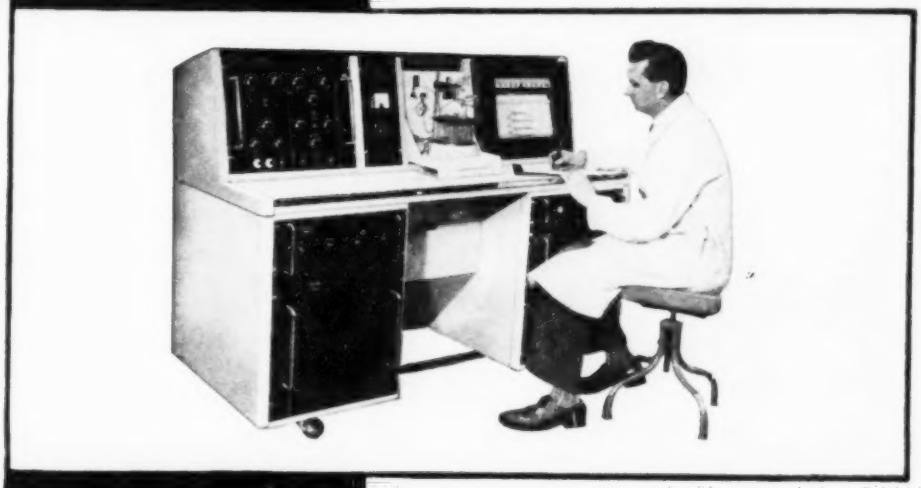

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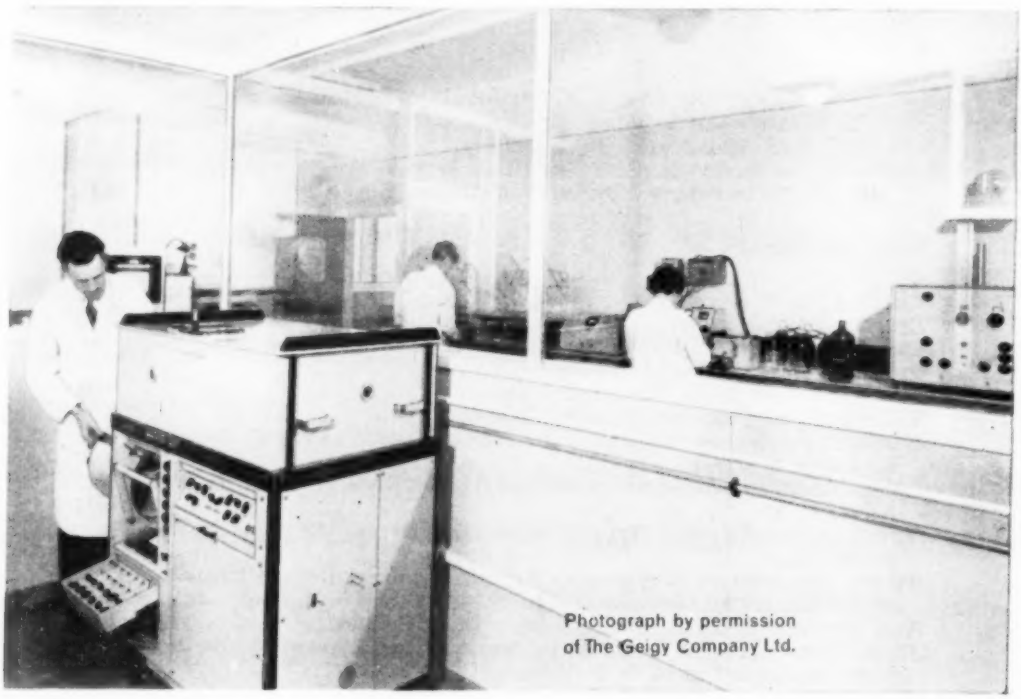

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TECHNICAL ASSISTANCE TO OVERSEAS COUNTRIES

THE Department of Technical Co-operation Bill, which received its second reading in the House of Commons on April 25, gives effect to the Government's decision, announced by the Prime Minister on March 11, to create a separate Department, under the charge of a Minister, to co-ordinate responsibilities and functions in regard to technical assistance to overseas countries which are at present divided between the Foreign Office, the Commonwealth Relations Office and the Colonial Office. The Minister will be known as the Secretary for Technical Co-operation, and his Department will be concerned with technical assistance, defined in the White Paper issued in March as "training in the United Kingdom and overseas, the provision of experts, administrators and other professional men and women, the provision of advisory technical and consultant services and expert missions, and the supply of equipment for training, demonstration, pilot schemes or surveys". It will not, as Sir Edward Boyle, Financial Secretary to the Treasury, emphasized at the outset of the debate, be responsible for the provision of capital, which will remain with the overseas Departments.

Sir Edward Boyle, who was moving the second reading of the Bill, said that at the beginning of 1960, about 47,500 overseas students were receiving training of some kind or other in Britain, of whom about 2,000 held some form of United Kingdom scholarship, and about 2,500 trainees have come to Britain under the technical assistance arrangements of the Colombo Plan, while 380 British experts have been employed under the Plan in south and south-east Asia. Altogether, some 6,000 professionally qualified officers were recruited in Britain to serve overseas Governments during the years 1955–60, although the table given in the White Paper* shows that the annual figure has declined from 1,467 in 1956 to 816 in 1960. Some of this educational assistance is at present handled by the Ministry of Education, the British Council, the Commonwealth Scholarship Commission and other bodies, and Sir Edward said that there is no intention of disturbing such arrangements where they were working well, though some marginal adjustment of responsibility may be necessary. In particular, he quoted the recruitment of specialists, such as biologists, as being handled more easily and efficiently if centralized in one department, irrespective of where the specialist was to serve. Sir Edward, in reply to a question about social services, to which the Bill refers, said that provision of medical services would certainly be included, as well as provision of experts to advise on starting a new industry or the provision of skilled administrators in every field.

* Technical Assistance from the United Kingdom for Overseas Development. Pp. 43. (Cmnd. 1308.) (London: H.M.S.O. 1961.) 2s. net.

An important responsibility of the new Department would be the administration of the scheme described in the White Paper last October for the continued employment of overseas officers. This scheme is expected to cost about £12 million a year. The responsibility for the transfer, promotion and discipline of the overseas service in dependent territories, however, would remain with the Colonial Secretary. The new Department will be concerned with the technical assistance which the United Kingdom provides through the United Nations, in particular the United Nations Expanded Programme of the Technical Assistance and Special Fund, and will take over the present work of the Technical Assistance Recruitment Unit of the Ministry of Labour, which recruits in Britain for service with the United Nations. It will also deal with technical assistance under the Colombo Plan and under the newly formed Special Commonwealth African Assistance Plan. It will be responsible, on behalf of the United Kingdom, for any technical assistance discussions in the Development Assistance Group and in the new Organization for Economic Co-operation and Development, and for the provision of technical assistance to a number of Middle East countries under the Central Treaty Organization arrangements and through the Middle East Division. The work of the British Council in education will retain its full importance, and the Ministry of Education will continue to be responsible for Britain's contribution to the United Nations Educational, Scientific and Cultural Organization.

Sir Edward anticipated that the staff of the new Department would number about 1,000, initially by transfer of posts and staff from existing overseas Departments and including about 550 from the directorates of the Overseas Services and the Overseas Geological Surveys, and its vote was estimated to be about £30 million, including certain expenditure now financed out of Colonial Development and Welfare Funds, but not involving any new expenditure. In replying on the debate, Sir Edward Boyle pointed out that British expenditure on technical aid had increased from £75 million in 1957–58 to about £100 million in 1958–59 and about £150 million in 1959–60, with a further £100 million of private investment in less-developed countries. He emphasized that there is no intention of changing the Government's policy in this respect, and that British commitments to the Colonies and under-developed countries are likely to increase. The Colonial Secretary is still responsible for more than thirty Colonial territories, and Sir Edward agreed that one of the dangers to be watched in operating the new Department is that of excessive consultation with the existing overseas departments hindering prompt decisions. He also agreed as to the importance of an

adequate supply of managers and engineers to enable the power stations and factories, etc., provided by technical aid, to be operated, that the relief of poverty in under-developed lands is one of the greatest moral challenges of our times, and as to the importance of bringing more people to Britain for training in skills which would be valuable in their own country when they returned; but he pointed out also that we should not think entirely of engineering and technical skills, and that it is important to make greater use of expert knowledge and skill.

The scale of the technical assistance already provided from the United Kingdom for overseas development is more fully displayed in the White Paper, which was freely quoted in the debate. This document includes among its annexes an impressive list of advisory committees and councils under the Colonial Office, and also of technical and other institutions in the United Kingdom which provide services overseas. Much of this service, like the contribution of private enterprise, clearly could not be included in the estimate of £150 million (£125 million bilaterally and £25 million multilaterally) given in the White Paper. The work of many of these bodies, like that of various advisory committees on research or the Colonial Development Corporation, is already known to many readers of *Nature*, though the White Paper gives some figures conveniently for reference. Thus, by the end of June 1960, the United Kingdom spent or formally committed for technical assistance to the countries of south and south-east Asia some £6,800,000, and the Government has declared its willingness to spend up to £9,000,000 for technical assistance under the Colombo Plan in the period April 1956–March 1963. Of this, about £1,585,000 was spent on the provision of some 380 experts and about £1,800,000 on equipment for training and research. About £6 million was contributed in 1960 to the various United Nations Technical Assistance activities—about double the amount contributed in 1959.

On the contribution of private bodies in the United Kingdom, the White Paper gives no information; but it refers with appreciation to the formation in 1958 of Voluntary Service Overseas, which will enable young men and women from the United Kingdom to serve as teaching and social welfare auxiliaries in the Commonwealth. This organization was welcomed in the debate in the House of Commons, though Mr. R. E. Prentice suggested that the new Ministry should initiate something on the lines of the Peace Corps started more recently by the President of the United States. Much more stress, however, had been laid on this aspect in a debate in the House of Lords on February 22, which dealt moreover with the fundamental purpose of technical aid—that of enabling the under-developed countries to raise their economies to a point where they could survive on their own. It is a combination of capital and technical skill that is required, and while these under-developed countries are at present receiving something like 4,000 million dollars a year, more than half of which is found by the United States, the United Nations Special Fund has only been able to support some 70 of the 250 projects for which it has received applications.

Lord Grantchester, after a tribute to the part Britain has played in establishing universities in its dependent or emerging territories, suggested that there is room for more co-ordination between the universities in dealing with overseas students. He also urged in particular the need for more individual advice for the students and the Governments of the countries from which they come. His suggestions for the establishment of training centres in London, where a limited number of students could obtain satisfactory training prior to entrance to a university, and for an alternative to the university course for overseas students, with particular emphasis on administration, seem worthy of consideration. Moreover, they are of the type where the initiative may well lie more fittingly with the Department of Technical Co-operation than with the Ministry of Education.

The Marquess of Lansdowne, who spoke for the Government, pointed out that if the effectiveness and volume of aid are to be increased, donor countries must encourage their experts—technicians, teachers and medical men—to serve where they are so vitally needed in the less-developed countries, concentrating on the projects of real value to the recipients and providing training facilities in their own countries. It follows from this that a Department of Technical Co-operation should be closely concerned with the establishment of the conditions which make it as easy and attractive as possible for professional men and women, as well as technicians, to serve overseas. This aspect was also urged strongly by the Bishop of Chichester. Suggesting first that it might be worth while examining our methods of rendering technical assistance in the light of ten years experience, he stressed the need especially to consider technical assistance in the context of educational assistance. The economic resources of a country cannot be developed fully without a continuing supply, from within that country, of technicians, administrators, and leaders of all sorts. He emphasized the need for public opinion to recognize and support the overriding need for teachers and educational assistance generally. He hoped that authorities in schools and universities will urge this opportunity on members of staff and students, and that technicians and scientists from industry may also contribute to such teaching for a few years.

Obviously, this is the point which the Duke of Edinburgh pressed in his Graham Clark Lecture to the Institutions of Civil, Mechanical and Electrical Engineers on April 13, and in the House of Lords debate Baroness Summerskill suggested that the universities should be assisted to establish supernumerary appointments so as to enable staff to go overseas. The Earl of Perth, who replied on the debate, referred particularly to the work of the Inter-University Council for Higher Education Overseas, and said that some £17 million from Colonial Development and Welfare Funds have been used for research and higher education; but the 30,000

students from the Commonwealth in British universities and technical colleges represent a further hidden contribution of some millions of pounds, including a very considerable effort in medical training. Scientists and technologists are already playing an important part in this effort; indeed, one theme of the Duke of Edinburgh's Graham Clark Lecture was that engineers have a responsibility to help in improving the material welfare of the poorer countries. It should also be remembered that a number of leading scientists have for many years been urging this responsibility and its implications on their colleagues.

At the Committee stage of the Bill on May 10, Sir Edward Boyle said that the Overseas Research Council will not itself be responsible for expenditure from Exchequer funds, but the new Department will, in general, take over research work in the United Kingdom which is now financed by the three overseas Departments, and in particular it will take over certain research work now financed from Colonial Development and Welfare Funds. Sir Edward also agreed as to the importance of the new Department having ample sources of information and that it is desirable that the new Department, which will have a small but important information branch, should give some publicity to its technical assistance work. Sir Edward's remarks did not, however, make the exact position of the Overseas Research Council very clear, and it is essential that the position should be carefully watched.

The debate on the Department of Technical Co-operation Bill scarcely touched on the aspect of capital investment, but some speakers were not entirely satisfied that capital aid is not within the Department's scope. Nevertheless, the debate showed that the interrelation of capital aid and technical aid, in the sense of personal service, is fully recognized, more so, perhaps, than in Dr. V. K. R. V. Rao's eighteenth Montague Burton Lecture on International Relations at Leeds last November*. In this lecture, on "International Aid for Economic Development: Possibilities and Limitations", which has recently been published, Dr. Rao, after reviewing the various attempts which have been made to accelerate the economic development of the backward territories with international and bilateral aid, suggests that all such aid should be internationalized and channelled through a modified International Development Association, for which he outlines a revised plan. He believes that such a scheme would deal automatically with the limitations at present placed on international aid—by resources, capacity for repayment or for absorption, or by the risk of demoralizing the recipient countries so that dependence replaces self-reliance.

The fundamental condition stressed by Dr. Rao, however, is a change in psychology, the recognition on the part of nations that they are all parts of the world, and that their citizens are all members of the human race. The establishment of a Department of Technical Co-operation certainly recognizes that need and should help to co-ordinate the British contribution both to British dependent territories and elsewhere. What is also required, however, is the clear understanding and firm support of those who will provide the expert knowledge, and for that reason alone the Department when it is established should receive careful attention by scientific and professional workers of all kinds, both individually and through their professional associations. There is nothing in the White Paper to suggest that weaknesses already apparent in regard to overseas research are recognized, and while the magnitude of the overseas research effort of Britain is not apparent either, that effort is sufficiently large in terms both of man-power and of expenditure for it to be important that resources should be wisely and efficiently used. Apart from that, however, the formation of the new Department should be a further stimulus to the constructive thinking as well as the personal service that are essential to enable technical assistance to match the opportunities becoming available, either in magnitude or in quality.

* International Aid for Economic Development: Possibilities and Limitations. By Dr. V. K. R. V. Rao. (Eighteenth Montague Burton Lecture on International Relations.) Pp. 29. (Leeds: The University, 1960.) 6*s*.

INSECT BIOCHEMISTRY

The Biochemistry of Insects

By Darcy Gilmour. Pp. xii + 343. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1961) 64*s*.

IN recent years an increasing number of biochemists have come to use insects as the source of their material for study; and entomologists studying the toxicology of insecticides have found the need for more knowledge of insect biochemistry. The time was therefore ripe for the appearance of this first text dealing with the subject. A difficult problem in such a book is how much introductory matter to include. The author assumes a general knowledge of chemistry and biochemistry; but whenever metabolic cycles or sequences are discussed the reader is tactfully reminded of the main outline of what is known of these processes in general biochemistry. Emphasis throughout is on what has come to be called 'dynamic biochemistry': the description of firmly established stepwise transformations and of the enzymes by which they are catalysed. The author recognizes the need for a sound basis of descriptive chemistry; but where well-controlled biochemical studies are lacking—as in the hardening of the insect cuticle—he makes the gap apparent to his reader.

There are large areas of the subject where the insect biochemist is mainly confirming the existence of processes already established elsewhere. But there are interesting variants, such as the predominance of glycerophosphate over lactate as the end-product of the glycolytic sequence in the flight muscles of some insects. Not all insect biochemistry, however, is of this derivative sort. In some quarters the insects lead the field. The cytochromes, which were soon recognized as the universal chain for electron transfer to oxygen, were discovered and characterized in the insect. Even the recent addition to the series, the microsomal cytochrome b_5, was discovered in an insect. The pteridines, which were first identified as inert pigments in the wings of butterflies—what

Gowland Hopkins called 'waste products that function in ornament'—seem ever to be increasing in metabolic importance as growth factors, photolabile receptors, co-factors for the transfer of 'active formate' and so on; and some of the most suggestive work is still being done on insects. Although best known in insects, the ommochromes and their relation to tryptophan metabolism are of general interest for the light they have thrown on gene action. The sclerotin of insect cuticle, formed by the quinone tanning of protein, constitutes a new type of natural polymer which still awaits biochemical analysis; and insects provide the ideal material for studying the biochemistry of morphogenesis.

The author recognizes physiology as a reputable discipline, but he does not allow himself to be diverted into physiological discussions, beyond the minimum necessary to link up his biochemical arguments. He always draws a clear distinction between what is surmised and what has been demonstrated. All this makes a book that is distinctive and stimulating in the sense that the reader feels a strong urge to go and fill the gaps in our knowledge. Almost every point made is documented by references to original work.

V. B. Wigglesworth

EVOLUTION AND PHILOSOPHY

The Ascent of Life

A Philosophical Study of the Theory of Evolution. By Prof. T. A. Goudge. Pp. 236. (London: George Allen and Unwin, Ltd., 1961.) 30*s*. net.

THIS book may be warmly recommended precisely because it gives a sustained philosophical discussion of modern evolutionary theory. It is eminently readable and its moderate tone should ensure for it a place on the bookshelf of every professional evolutionist. This is not to say, however, that the arguments in the book are wholly convincing or without blemish. The philosophical approach is chiefly that of the neo-positivist or empiricist, and this approach has clearly limited the scope and value of the book. Prof. Goudge seems to consider that a philosophical explanation, while going beyond the empirical facts and assumptions, is somehow immanent in them but cannot be transcendent to them unless capable of empirical application. This point of view would again seem to narrow the value of the interpretations given. I am sure many people consider that the value of a philosophical explanation of a biological theory is precisely because it may go far beyond the theory into a wider realm of meaning which the theory may have for us in both our sentient and intellectual lives.

After an introduction and a second chapter, which is described as historical but does not give much actual history, Prof. Goudge begins the main chapters of the book. The evolutionary theory mainly considered is that of modern selection, and even here this explanation is practically limited to evolution in the light of population genetics. A certain courage is here manifested by the author because population genetics is new, highly abstracted, speculative, and its models are greatly simplified versions of the real picture. It may be fashionable to consider that evolution occurs through 'populations', but it is a serious mistake to give a philosophical account of evolution which implies that evolution occurs only by this method. There just is no evolutionary or genetical reason why a single individual (or a single pair) of organisms should not start, or have started, a new evolutionary line. This is a point which is important in considering the evolution of man, and it is missed completely by Prof. Goudge.

Other legitimate biological theories which are often misunderstood and have never been philosophically refuted, such as vitalism, finality or neo-Lamarckism are, indeed, mentioned but are unfortunately given scant treatment. On the question of finality alone the fundamental point, that without the assumption of finality many scientific statements could scarcely even be made, is ignored. It is a pity also that the basic assumptions of the theory of evolution are not given any philosophical treatment. Nevertheless, there is a wealth of ideas and suggestions in this book which should enlarge the vista of the evolutionary biologist.

P. G. Fothergill

HUMAN GENETICS

Recent Advances in Human Genetics

Edited by Prof. L. S. Penrose, with the assistance of Helen Lang Brown. Pp. vii+194. (London: J. and A. Churchill, Ltd., 1961.) 27*s*. 6*d*. net.

HUMAN genetics is now a branch of biology with its own methods. This is due largely to Penrose on the genetical side, and Tjio and Levan on the cytological. This small book is not a text, but consists of eight chapters by Penrose and six colleagues. In the first chapter Penrose summarizes recent work on human mutation-rates and their dependence on age. He is sceptical of the high rates (median 28 mutations per chromosome per generation) estimated for autosomal recessive defects, as compared with a median value of 6 for dominants. He believes that they often are or have been advantageous to heterozygotes. The data on ages of parents of mutants are equally interesting, and make it clear that mutation at different loci must be due to wholly different processes. Harnden and Miller deal with chromosomal abnormalities, and some sexual abnormalities in chromosomally normal people. The most striking item in Penrose's chapter on foetal genetics is perhaps the map on p. 71 showing the distribution of anencephaly in Europe, with one peak in Ireland and western Britain, and another around Naples.

Gerald's article on the abnormal haemoglobins is a useful snapshot of a very rapidly developing subject, and contains some 'stop-press news' which very much interested me. The subject will probably remain a little confused until a new technique is devised which will be as quick as electrophoresis, and which can distinguish between some chemically different variants that are not electrically separable. Holt deals with the ridge patterns of fingers and palms, which are among the most accessible of human characters, and, in view of the correlations exceeding 0·95 between monozygotic twins, must be mainly determined genetically. The last two chapters are largely statistical. Renwick describes the search for human linkage, and its estimation, while Smith deals mainly with other statistical problems, including his own remarkably efficient iterative method.

To a reader who had been cut off from reading for as short a time as two years, the chapters on chromosomal abnormalities and sex determination would be the most striking. Two years hence we should know a great deal more on these matters. But the whole book is very good. It is not free from errors, for

example, the statement on p. 87 that "individuals heterozygous for the gene determining *Hb S* invariably possess both *Hb A* and *Hb C*". This is corrected later in the same paragraph. However, I have detected no serious mistake. It can be read with great benefit by students of other branches of genetics, and of medicine. Some knowledge of both genetics and pathology is assumed. The alternative would have been to double the volume and price of the book. Helen Lang Brown, who helped in editing, and was almost surely responsible for the very full bibliography with 526 references, deserves special thanks.

J. B. S. HALDANE

TECHNICAL APPLICATIONS OF FRESHWATER BIOLOGY

Handbuch der Frischwasser- und Abwasser-Biologie. Von Prof. Hans Liebmann. Band 2. Lieferung 1: Pp. xi + 1–160. Lieferung 2: Pp. 161–320. Lieferung 3: Pp. 321–480. Lieferung 4: Pp. 481–640. Lieferung 5: Pp. 641–800. Lieferung 6: Pp. 801–960. Lieferung 7: Pp. 961–1149. (München: R. Oldenbourg, 1960.) 20 D.M. each number.

THIS volume is the second of a pair. The first, published in 1951, dealt with freshwater biological methods and the most important chemical techniques which are needed to supplement them. It contained also an exhaustive treatment of the indicator organisms which can be used in the study of pollution, and a new exposition of the Kolkwitz and Marsson *Saprobiensystem*, which is widely used in Europe for assessing organic pollution.

The two volumes are intended to be used together, and the second contains many references to the first. In both, the emphasis is on the 'application' of biological knowledge to water technology, and although much basic freshwater biology is included it is clear that the author intends this only as a background. This approach to a subject which is often regarded as primarily academic should commend itself to readers in many disciplines concerned with the uses of water in their widest sense.

The second volume begins with a discussion of the various processes which result in natural self-purification of organically polluted waters, and this leads to a brief survey of the biology of waters in general, including artificial lakes and reservoirs. It then considers drinking water, with special reference to its origin, since the organisms which occur, or develop, in it vary according to whether it comes from underground or surface sources. Here also are described the various filtration and other methods which are normally employed, and the biological problems which may arise in their use, as well as the difficulties caused by water blooms and their control. A similar, shorter, chapter deals with swimming pools and spas.

A further section covers freshwater fisheries of all kinds, from natural rivers and streams to fish farms, and here again the emphasis is on practical management.

The author then discusses the methods of sewage purification, with particular reference to the biological processes involved. This section is a mine of information on the various processes in use on the Continent, including some, such as fish ponds, sewage ponds and irrigation, which are not used in Britain, but which might well be considered for introduction. Many readers of biology could learn much about civil engineering from these chapters, as could engineers about how their steel and concrete structures enable micro-organisms to purify effluents. Of particular interest are the accounts of the use of sewage in Munich for rearing carp, and of the biology of trickling filters and activated sludge.

The final section, written in collaboration with Dr. H. A. Stammer, gathers together the scattered literature on the toxicity of inorganic and organic chemicals to freshwater organisms, and the effects of suspended solids and high temperature on fish. It will be most useful for reference.

The book is well illustrated with photographs, and contains diagrams from many original papers. It ends with a hundred closely printed pages of references and a good index. It is, in short, an excellent book to have on one's shelf, or in the nearest library, and Dr. Liebmann is to be congratulated on having performed such a Herculean task.

I have, however, some criticisms. First, 140 D.M. is a very high price for any book, and for this one it seems unnecessarily high. Many points are discussed several times, and liberal application of a blue pencil could have made the book much shorter with no loss of content. Moreover, many figures are reproduced two or three times. There is also a very large number of misprints, only some of which are corrected in three pages of errata. Many of these involve the names of invertebrates, and Dr. Liebmann would have been well advised to submit the proofs to a zoologist. This would also have saved him from calling *Suberites* a freshwater sponge, mislabelling at least three of his photographs and making several other unnecessary mistakes. More careful editing could have removed these blemishes and lowered the price.

H. B. N. HYNES

PROTON RESONANCE

Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry By L. M. Jackman. (International Series of Monographs on Organic Chemistry, Vol. 5.) Pp. xii + 134. (London and New York: Pergamon Press, 1959.) 35*s*. net.

FROM birth to maturity, the application of nuclear magnetic resonance to problems in organic chemistry spans a period of only five years. Dr. Jackman's book is therefore timely, for which both author and publisher are to be congratulated.

The questions that nuclear magnetic resonance is asked to solve in organic chemistry are: (1) What types and number of protons can be distinguished by their chemical shift? (2) What information about the environment can be obtained when the spin-coupling components are resolved? Both topics are treated in the book although, appropriately (1) is dealt with more thoroughly. While many important spectra are described and analysed, the theoretical content is strongly qualitative, and it is possible to doubt if this severely practical outlook really conveys the elements of the subject to the uninitiated. This is perhaps not the purpose of the book, but it fails to meet the condition that the full deployment of nuclear magnetic resonance in problems of structure involves a better appreciation of its principles than, for example, ultra-violet or infra-red spectroscopy.

An account of the general theoretical and experimental background is followed by two central chapters dealing with the relationship between proton shifts and chemical structure. The information summarized here will be of immense value to structural chemists, and it is likely that the carefully assembled tables will form part of the intellectual furniture of organic laboratories for a considerable time: in fact, the exposition and illustration of factors governing the chemical shift form the strongest part of the book. Spin-spin interactions are described in a subsequent chapter wherein the position is a less happy one. The discussion ranges from examples of AB coupling which are readily apprehended even in large molecules to complex cases, for example A_2B_2, where complete resolution can only be accomplished with great difficulty. The tendency to quote, without derivation, formulæ for the frequencies and intensities of lines in a spin multiplet is unfortunate if spin-coupling constants are to be fully exploited as instruments for structure determination. It would seem that an account of electron-coupled interactions in terms that will commend themselves to organic chemists has yet to be achieved.

The book is well produced and illustrated, though misprints are fairly common. There is no doubt it will occupy a place in the bookshelves of most, if not all, organic chemistry laboratories.

J. C. D. Brand

WAVE MOTION OF OCEANS AND ATMOSPHERES

Hydrodynamics of Oceans and Atmospheres

By Carl Eckart. Pp. xi+290. (London and New York: Pergamon Press, 1960.) 63*s*. net.

THIS book has a misleading title in the sense that it is neither a balanced introduction nor a treatise on the hydrodynamics of oceans and atmospheres. The dust cover and preface hint at a narrower topic; the list of contents makes it clear. Most of modern dynamic oceanography and meteorology—general circulation, weather prediction, current and wind structure, interaction of wind and sea, turbulence, diffusion, internal friction—are scantily treated, if at all. In fact this book is a monograph, suitable for research workers in geophysical fluid dynamics, on wave motion in an inviscid fluid. Its approach is akin to that taken by the Norwegian school of meteorologists in their book *Physikalische Hydrodynamik* of 1933. Prof. Eckart considers the effects of compressibility, vertical variation of density, gravity, and Coriolis force, but not instability due to shear in the unperturbed state of equilibrium. To this limited topic he applies new methods, drawn from his great experience of mathematical physics.

The perturbation equations for various basic states are set up in the opening Chapters 1–5. At the same time, the time-mean motion of the Earth's atmosphere and sea is discussed perfunctorily, and some simple stationary models for the basic state are described in Cartesian and Mercator co-ordinates. The remaining chapters, 6–17, contain an original and powerful treatment of the perturbation equations. Ray theory of geometric optics, the Wentzel–Kramers–Brillouin approximation, and Sturm–Liouville theory are used for a variety of cases depending on the basic variation of density, and on the neglect or retention of the Earth's rotation and of the curvature of the geopotential surfaces. This treatment embraces and unifies much classical work on sound, internal gravity waves, Lamb waves, tides and Rossby waves.

Throughout the text are remarks claiming the importance of linear wave-motion. The arguments are broadly of three kinds: those that maintain the physical relevance of wave motion, those that deny the adequacy of other theories, and those that promote wave theory as a first step toward understanding more complicated phenomena such as turbulence. Lack of space has prevented the author from properly discussing rival theories or observations of the sea and atmosphere, so I have yet to be convinced that wave-motion is more than one of many topics important in geophysical fluid dynamics. However, to this one topic the author has made an extensive and original contribution.

P. G. Drazin

MAN AND HIS ANCESTRY

Man and His Ancestry

By Alan Houghton Brodrick. Pp. 256+16 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1960.) 35*s*. net.

THE recent spate of semi-popular books on man and his ancestry has given the reader a wide choice. This one is useful for reference purposes since it covers a wide field and quotes many of the sources. It includes a good many new discoveries which are not widely known outside specialist journals (for example, the post-war hominid remains from China and the Neanderthal footprints cave at Toirano) and the author has some stimulating ideas about familiar facts. There are chapters on "What is Man?", "The Genealogy of the Apes", "The Discovery of Man's Antiquity" and others on the Australopithecines, the Pithecanthropoids, the Neanderthaloids and *Homo sapiens* fossils. Each chapter is divided by numerous sub-headings which help to lessen the confusion caused by rapid leaps from one subject to another.

Inevitably, Mr. Brodrick's book will be compared with *Mankind in the Making* by Prof. W. W. Howells; both have appeared within the past few months and cover essentially the same ground, both are easy to read and sprinkled with anecdotes. But while Prof. Howells is a trained anthropologist who can be relied on for accuracy, the general reader (for whom *Man and his Ancestry* is presumably intended) will be badly misled if he accepts all Mr. Brodrick's statements.

The Australopithecines are said to have lived more than a million years ago; and the beginning of the Pleistocene is set at "about two or possibly three million years ago". The Ternifine fauna is stated to be post-Villafranchian "as the presence of *Equus* indicates" (*Equus*, of course, first appeared during the Villafranchian, as the author himself points out earlier in the book). Apart from a good many minor inaccuracies of this kind, there are more serious misinterpretations. The principles of natural selection, for example, seem to have been overlooked: "Apes do not have long arms because th y live in trees, they live in trees because they have long arms".

If most of this review has been taken up with criticisms, it is in the hope that the faults will be corrected in subsequent editions. If this were done, the book could be thoroughly recommended as a lively introduction to the subject of man and his ancestry. SONIA COLE

PHYSIOLOGY OF EFFECTOR ORGANS

Vergleichende Physiologie

Von Prof. W. von Buddenbrock. Band 5: Physiologie der Erfolgsorgane. (Lehrbucher und Monographien aus dem Gebiete der Exakten Wissenschaften. Reihe der Experimentellen Biologie, Band 10.) Pp. 390. (Basel und Stuttgart: Birkhauser Verlag, 1961.) 54 D.M.

WHEN, in 1936, W. von Buddenbrock published the second edition of the *Grundriss der vergleichenden Physiologie*, the rapid development of comparative physiology had made necessary a subdivision of the work. The first volume was devoted to the sense organs and the nervous system. The comparative physiology of the effector organs was the subject of Volume 2 of the new edition. After the War von Buddenbrock undertook the Herculean task of revising the whole work and incorporating it in the enormous advances in the subject that had been made, especially in the English-speaking world, immediately before and during the War. The result was the publication of a work in which Volumes 1 and 2 were devoted to sensory physiology and nervous physiology respectively. Nutrition, water and mineral economy were dealt with in Volume 3 and the comparative physiology of hormonal control in Volume 4. The present volume, the fifth in the series, is devoted to the comparative physiology of effector organs. These include muscles, cilia, flagella, chromatophores, luminous and electric organs, but there is no account of glandular effectors. A sixth volume dealing with blood, heart and respiration is in preparation.

Volume 5 is a consistent and equal partner to the preceding volumes of the work. It shares with them both their merits and their faults. On the merit side it can be said that the treatment of the subject benefits from the author's wide-ranging insight into the fundamental biological problems as well as his astonishingly up-to-date information on modern trends in research and their theoretical implications. Especially the chapters on muscle, colour-change, luminous and electric organs well bear out his claim of having incorporated the literature up to and, in some cases, including 1959. This has enabled him at least to sketch out an account of the results of modern experimental work against a background of older observational data. The faults may be considered inherent in an attempt to present comparative physiology in its entirety in a work of 6 volumes written by one author, at a time when a comparative monograph on muscles alone has appeared filling 3 volumes written by a galaxy of experts. As a reference work, then, and a progress report, the book is bound to fall short of the research worker's needs. Its usefulness as a text-book, quite apart from its bulk and price, is also doubtful. The author, having introduced a wealth of frequently conflicting research data, is justifiably reluctant to arrive at the sort of generalizations on which a student depends on to find his way into, and about, a new subject. More often than not, the student is left with a shrug of eminent shoulders where he has been looking for guidance, if only in guessing.

Thus it may well be that the book's justification and importance lie in its use by the academic teacher, especially in German-speaking countries. To him it can be an invaluable guide to the literature not least by means of the excellently arranged lists of references divided into various categories, namely review articles, older original papers and recent publications.

The volume, like the others, is well illustrated and contains many tables of qualitative and quantitative research data. The style is as lucid as ever, and the presentation bears witness to the unflinching enthusiasm, scientific honesty and wisdom of a man who has, perhaps, contributed more than any other towards the creation, moulding and consolidation of comparative physiology as an important branch of biological science. O. LOWENSTEIN

REPRODUCTION IN ANIMALS

Marshall's Physiology of Reproduction

Vol. 1, Part 2. Edited by Prof. A. S. Parkes. Third edition. Pp. xx+877. (London: Longmans Green and Co., Ltd., 1960.) 240s. net.

THIS is the third volume of the third edition of Marshall's *Physiology of Reproduction* to appear since 1952. The fourth and final volume is due to be published within the next twelve months.

The major part of the present volume is devoted to reproduction in the male (spermatogenesis, structure and metabolism of spermatozoa, natural and artificial insemination) and fertilization. These topics have been studied so extensively since the 1922 edition of Marshall's book that some 400 pages are necessary to summarize present-day knowledge (as against 80 pages devoted to the topics in the previous edition). It is a tribute to the editor, Prof. A. S. Parkes, and his team of distinguished authors (including the late Dr. Arthur Walton, Dr. C. R. Austin, Dr. M. W. H. Bishop, and the editor himself), that the present volume maintains the high standard of workmanship, elegant style and accuracy that we have been led to expect from the preceding two volumes.

The chapter on gonadal and gonadotrophic hormones in lower vertebrates, contributed by Prof. J. M. Dodd, provides the best comprehensive review published hitherto of this new and rapidly expanding subject. The chapter is amply and beautifully illustrated, and will be invaluable to zoologists and physiologists alike. The penultimate chapter, by Prof. A. S. Parkes and Prof. A. J. Marshall, deals with reproductive hormones in birds. The last chapter, on external factors in sexual periodicity, was drafted by F. H. A. Marshall before his death, and has been revised and brought up to date by Prof. E. C. Amoroso. It deals with many controversial topics, which are stated with both clarity and impartiality, and will prove of immense value to the many workers currently engaged in research in this field.

It is unfortunate that the volume lacks a table of contents of the preceding two volumes, and it is to be hoped that the final volume will carry a cumulative list of contents for the whole series.

Although the price of this volume is high, there can be few serious students of reproductive physiology who can afford to be without it. ANITA M. MANDL

Resonance Absorption in Nuclear Reactors

By Lawrence Dresner. (International Series of Monographs on Nuclear Energy. Division 10: Reactor Design Physics, Vol. 4.) Pp. x+131. (London and New York: Pergamon Press, 1960.) 40s. net.

AN important problem in the physics of nuclear reactor design is to predict the proportion of neutrons lost to the chain reaction by absorption in the nuclear resonances of uranium-238 and other elements. During recent years the accumulation of basic experimental data on resonances has enabled reactor physicists to attempt to calculate the absorption directly from neutron transport theory, as an alternative to the customary use of empirical methods.

The present monograph gives a timely account of modern theoretical work in the field, as well as a critical comparison of theory with experiment. It is primarily intended for those well versed in reactor physics, and contains little on the more descriptive type of theoretical treatment developed by the early workers.

There are two introductory chapters giving a brief historical survey and an account of the general transport theory of neutron slowing-down in absorbing media. The greater part of the book is devoted to the development of approximate methods to deal specifically with resonance absorption in homogeneous and heterogeneous systems. Various special topics are discussed, for example, the interaction between neighbouring absorbers, and the Doppler broadening of resonances due to rise in temperature. The only significant omission noted is an explanation of the empirical formulæ used for representing the experimental results. A critical discussion of these formulæ in the light of the preceding theoretical chapters would have been desirable.

A valuable feature of the book is the orderly presentation of key results from many published papers and official reports. It can be warmly recommended.

J. Codd

Plant Physiology

A Treatise. Edited by F. C. Steward. Vol. 1B: Photosynthesis and Chemosynthesis. Pp. xvii+348. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 12 dollars.

THIS volume contains two articles, a longer one extending to 242 pages of text by H. Gaffron on the mechanism of photosynthesis, and a shorter one of 37 pages by M. Gibbs and J. A. Schiff on the energy relations of chemo-autotrophic bacteria. Both articles are followed by an adequate list of references.

The work of Van Niel in 1931 on photosynthetic bacteria, the discovery of the chloroplast or Hill reaction some eight years later, and subsequent work with radioactive isotopes, aimed at discovering the fate of the carbon in the carbon dioxide absorbed in photosynthesis, led to views on the mechanism of photosynthesis which are now generally, though not universally, supposed to involve the photolysis of water and the incorporation of the absorbed carbon into a phosphorylated pentose, giving a substance from each molecule of which two molecules of a phosphorylated triose, phosphoglyceric acid, are produced. In the present volume Gaffron gives a detailed account of all the processes and reactions involved in photosynthesis as suggested by recent researches and of the findings on which present-day views are based. The mechanism of photosynthesis is obviously a very complex one, and the botanist who comes to read this account without some acquaintance with the present position of the subject may find some of it, particularly the part dealing with photochemical considerations, rather difficult reading. The arguments for the views adopted are put forward very fairly.

The small article on the energy relations of chemo-autotrophic organisms brings together what is known concerning chemosynthesis in nitrifying, nitrating and non-photosynthetic sulphur bacteria, and will be found useful by those requiring information on this topic.

W. Stiles

Birds of the West Indies

By James Bond. Pp. 256 + 8 plates. (London: William Collins, Sons and Co., Ltd., 1960.) 35s. net.

THIS is a field guide to 429 species of which 266 are illustrated, 80 being in colour. There are short descriptions of the main features of each family, which will be a help to the novice in the absence of keys. The text of each species consists of the usual descriptive material, including local names, a useful addition in a region where several languages are in use. Mercifully there are no sub-species.

Colour figures are mainly good; the line drawings have rather too much detail for the size reduction and are inclined to be fuzzy, though this may be partly the fault of the paper used, for the letters of the text also are sometimes lacking in sharpness.

James Bond has been associated with ornithology in the West Indies for half a lifetime, and his knowledge of the birds of that region is unequalled. This illustrated guide will be a great boon to professional and amateur, even traveller and visitor with the most casual interest in birds.

Servomechanisms

An Introduction to the Practice and Theory of Closed-Loop Position-Control Systems, with an Account of Methods of Data Transmission and Computation. By P. L. Taylor. (Electrical Engineering Series.) Pp. xiv+418. (London: Longmans Green and Co., Ltd., 1960.) 42s. net.

MR. P. L. TAYLOR, who has had considerable experience in teaching the theory of control systems to students of aeronautical and other branches of engineering, has written this introductory text-book for use in technical colleges and universities. It has refreshing elements of novelty in substance and arrangement. Within its intentionally limited scope, it is well adapted to the needs of both students and lectures.

The analysis is developed in a simple manner using, in the first half of the book, no more mathematics than simple linear differential equations. An account of such physical elements as are involved in measurement, data transmission, operation and analogue computation is given in the second chapter.

The second half of the 400 pages develops the theory of linear continuous systems, proceeding via an excellent summary of the essential properties of the complex variable to the Laplace transform, leaving the response to sinusoidally varying input quantities to be developed by an application of the Laplace transform. This sequence is not the usual one, partly because the teaching of the analysis of linear systems with sinusoidal inputs can usually presume familiarity with the techniques of electrical

engineering, and partly because the physical significance of the relationships between sinusoidally varying quantities is more obvious than that between Laplace transforms. It is an interesting feature, but one that will not find favour with all teachers.

The book is confined to linear systems, except for one chapter that describes the effect of certain simple types of non-linearity, but it satisfactorily covers such matters as root loci and phase-gain diagrams. There is no discussion of on-off or sampled data systems, or of any form of discontinuous operation, or of the behaviour with randomly varying inputs. The book is thus essentially an introductory one but, within its scope, it is very good. The emphasis is on physical rather than mathematical explanations. A good selection of problems and exercises is included, with answers and hints for solution. The book is likely to be widely used in connexion with courses of limited scope, where at the commencement of the course the students have only a limited knowledge of the required mathematics. A. TUSTIN

Abstract Set Theory

By Prof. Abraham Fraenkel. Second, completely revised edition. (Studies in Logic and the Foundations of Mathematics.) Pp. viii + 295. (Amsterdam: Elsevier Publishing Company, 1961.) 60*s*.

THE second edition of this book is in many respects different from the first edition. Its size has diminished from 479 to 295 pages; the first sections have been made more concise, remarks of secondary importance and references to literature of minor significance have been omitted. New material has been added in the text, and exercises, based on publications which have appeared during the decade 1950–1959. The bibliography has been greatly reduced, only those works actually referred to in the book appearing therein.

In the text there are three chapters. Chapter 1 on foundations, the concept of cardinal numbers; Chapter 2 on equivalence and cardinals; Chapter 3 on order and similarity, order types and ordinals. In these chapters there are sections on Cantor's set concept, finite and infinite sets, denumerable sets, the continuum, transfinite cardinals; arrangement of cardinals by magnitude, addition and multiplication of cardinals, exponentiation of cardinals, transfinite numbers and infinitesimals; ordered sets, similarity and order-types, linear sets of points, general theory of well-ordered sets, ordinals and alephs, well-ordering and comparability, the origin and significance of set theory.

The book is very ably written, and will be of great value to undergraduates (and some postgraduates), and to mathematical philosophers. R. G. COOKE

Name This Insect

By Eric Fitch Daglish. Revised edition. Pp. xxvi + 294 (64 plates). (London: J. M. Dent and Sons, Ltd. 1960.) 21*s*. net.

THERE are said to be some 20,000 species of insects to be found in the British Isles, and possibly a million in the world. The author of a book for their identification in 300 pages of small octavo, fitting easily into the pocket, has clearly performed a feat of selection and compression.

It can be said at once that Mr. Daglish has done this most competently, within the limits that he has set himself. He has chosen some 700 British insects and presented them in the form of a key, using only such characters as can be seen at a glance, and avoiding almost all technical terms. The intention is that anyone on a country walk may carry the book, and use it to identify any insect that is big enough, or brightly coloured enough to attract his attention. The small, the obscure, and the rare insects are ignored.

The keys are clearly set out, but would be easier to use if the details of habitat and distribution were more distinct from those of colour and appearance. There are rather few text-figures; perhaps it would be difficult to have had more without introducing the technical terms that the author has avoided. The 64 plates show the appearance of 360 species, and are generally good pictures poorly printed, especially those in colour. Some are arbitrarily labelled 'all enlarged', though in fact they may be natural size, or even smaller.

Many serious entomologists would condemn such a key for giving a spurious appearance of precision, when scarcely one British insect in thirty is included, but one should not rely on any key for precise identification. The best of keys is no more than a guide, eliminating some possibilities and suggesting others. The fact that this book has been revised and reprinted after eight years suggests that the public for which it is intended has found it helpful.

HAROLD OLDROYD

Mineraly

Spravochnik. [Minerals: a Reference] Book. Vol. 1. (In Seven Volumes.) Pp. 617. (Moscow: Academy of Sciences, 1960.) 3.5 new roubles.

EARLY last year the U.S.S.R. Academy of Sciences announced the forthcoming publication of the first comprehensive compendium of mineralogy to be compiled in the Soviet Union. From the first of the promised seven volumes of this work it is now apparent that the compilation will be of outstanding importance, in many respects comparable to the seventh edition of Dana's *System of Mineralogy* (the two published volumes of which were translated into Russian in 1950 and 1954), but differing from this leading Western authority in paying much more attention to Russian research work. This initial volume sets a high standard and seems to be unusually free from errors, even in references to Western literature. It covers the native elements and intermetallic compounds, carbides, nitrides and phosphides; arsenides, antimonides and bismuthides; sulphides; selenides; and tellurides. The index lists close on 1,500 names of these minerals, printed both in Cyrillic and Roman characters. The second volume will deal with halides and oxides, Volumes 3 and 4 with silicates, Volumes 5 and 6 with other oxygen compounds, and Volume 7 with phase-equilibrium diagrams. For each mineral is given the preferred name, formula, etymology and synonyms, diagnostic characteristics, crystal structure and morphology, chemistry, behaviour on heating, occurrence in Nature, alteration, practical significance, means of distinction from similar minerals, and a selected bibliography. The editors-in-chief are F. V. Chukhrov and E. M. Bonshtedt-Kupletskaya, aided by G. P. Barsanov, N. V. Belov, and the late O. M. Shubnikova. Another 19 authors have collaborated in producing the first volume. This new text will undoubtedly rank with Dana's *System* as a principal reference work in any internationally minded mineralogical laboratory. C. F. DAVIDSON

THE ORIGIN OF OCEAN BASINS AND CONTINENTS

By Dr. J. J. GILVARRY
Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin

RECENT reviews of the problem of the origin of ocean basins and continents have been given by Howell[1], and by Jacobs, Russell and Wilson[2]. The classical hypotheses in this connexion are the tidal resonance theory of Darwin[3], involving creation of the Pacific Ocean by escape of the Moon, the theory of migrating continents originated by Taylor[4] and Wegener[5], and the various theories based on thermal convection[6]. Most such theories were devised without taking into account a discovery of the last decade that the Mohorovičić discontinuity rises from its depth of about 33 km. under the continents to within about 5 km. from the floors of the oceans. This fact implies a profound difference in the structures of ocean basins and continents[7], which creates grave difficulties for most theories of the origin of these features, in particular for the theory of migration of continents[8].

In a recent article[9], I suggested that the circular lunar maria are simply large meteoritic craters with sedimentary floors, excavated by explosive impact of meteorites on the lunar surface in the presence of a hydrosphere. The purpose of the present article is to propose an exactly analogous mode of formation of ocean basins, as the results of explosive impact of large meteorites at a pristine time when the hydrosphere covered the Earth to a roughly uniform depth. The disparity in the levels of the Mohorovičić discontinuity under continents and oceans enters the theory as an integral part.

My attention has been directed by the Editors of *Nature* to a paper by Harrison[10] which appeared about the time the original manuscript of this article was submitted for publication. Harrison hypothesizes that the Pacific Ocean was created by impact of a planetesimal, a terrestrial satellite, or a satellite of the Earth–Moon system, and conjectures a similar mode of formation for every ocean. Thus, the conclusions presented here, arrived at independently, are identical in principle with the suggestions of Harrison, but the basis of the argument is entirely independent and the proposed mechanism of crater formation differs in an essential respect. The reasoning of the present article is based on a reconstruction of the mensuration of the pristine oceans, and a correlation of their dimensions with those of the lunar maria, lunar craters (of Class V), and meteoritic and explosion craters in water[9]. Thus, the presence of a terrestrial hydrosphere at the time of formation of the ocean basins is an essential element in determining the relative dimensions of the pristine craters. In contrast, Harrison's basic argument is that creation of the Pacific Ocean by the impact of a planetesimal or satellite is energetically possible.

Origin of Ocean Basins

The largest terrestrial ocean, the Pacific, can be divided geologically into two major basins, the North Pacific and the South Pacific, by prolongation to the coast of South America of an east–west line coinciding approximately with the andesite line north of Australia. On the side of the andesite line away from the Pacific, the rocks tend to be continental in type. A similar natural division of the Atlantic into the North Atlantic and the South Atlantic can be made by a line joining South America and Africa at their closest points, roughly between Cape São Roque and Cape Palmas. With these divisions, each of the five oceans, the North Pacific, the South Pacific, the North Atlantic, the South Atlantic, and the Indian, possesses a roughly circular outline.

At the seaward limit of the continental shelf, the demarcation of each oceanic basin is an escarpment as precipitous as that forming the boundary of a lunar mare of the type of Mare Imbrium. Thus, the terrestrial oceans possess at least two features, a roughly circular outline and an encircling scarp, in common with the lunar maria of Imbrian type. A third common feature exists: as is the case with the lunar maria, the floors of the oceans lie below the mean level of the land mass. In view of these similarities, it will be postulated that the terrestrial oceans and the lunar maria of Imbrian type were formed in the same manner, by explosive impact of large meteorites in the presence of a hydrosphere. At the outset, it should be emphasized that the hypothesized meteorite impacts occurred far back in the Pre-Cambrian era (a period of time lasting about four milliard years)[11].

In the case of the lunar maria, my argument on the mode of formation was based on a correlation of their dimensions with those for explosion and meteoritic craters formed in water. For the present terrestrial oceans exclusive of marginal seas, the diameter D and depth d' are shown in Table 1, as determined from data of Kossinna[12]. For simplicity, the line of division between the North Pacific and the South Pacific, and between the North Atlantic and the South Atlantic, has been taken as the Earth's equator. Because of the inherent uncertainties, no effort has been made to correct the entries for the Pacific Oceans to take account of the location of the andesite line. The diameter shown is an equivalent diameter D fixed from the ocean area A by:

$$\tfrac{1}{4}\pi D^2 = A \qquad (1)$$

The depth d' appearing corresponds to the maximum given by Kossinna for which a significant floor area of the ocean exists; it includes 1 km. corresponding to the mean height (840 m.) of the continents[12].

Table 1. Mensuration of Ocean Basins

Ocean	D (km.)	d' (isostatic) (km.)	d (anisostatic) (km.)	l (anisostatic) (km.)
S. Pacific	11,000	10·5 ± 0·5	39 ± 4	22 ± 2
Indian	9,700	8·5 ± 0·5	34 ± 3	19 ± 2
N. Pacific	9,500	10·5 ± 0·5	34 ± 3	19 ± 2
S. Atlantic	7,600	8·5 ± 0·5	27 ± 3	15 ± 2
N. Atlantic	6,800	9·5 ± 0·5	24 ± 2	14 ± 1

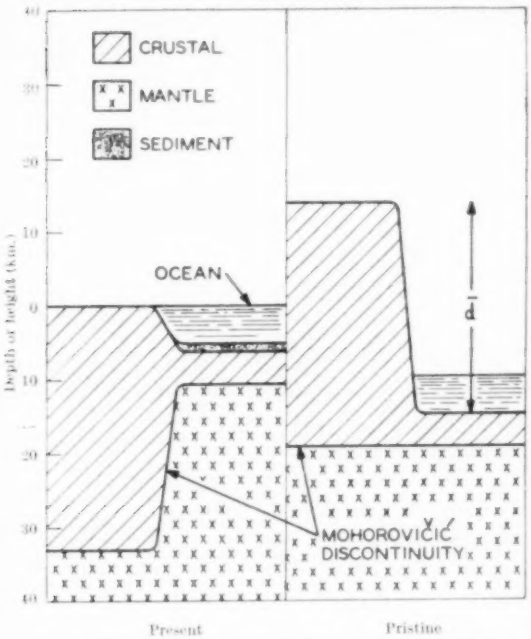

Fig. 1. Standard sections through rocks under continents and oceans at the present time (left), compared with corresponding pristine sections (right) immediately after the impacts of the meteorites forming the oceans

The values of ocean dimensions in question cannot be made the basis of a correlation with the corresponding dimensions of the lunar maria because the terrestrial ocean basins are, and have been, subject to isostatic compensation. On the other hand, the evidence is strong that the Moon is not and never was in hydrostatic equilibrium, in view of its strongly triaxial shape. This shape reflects the strength of the component materials, and is consistent with a cold origin for the Moon[13,14]. However, even if the Earth were formed cold, radioactive heating certainly would be sufficient[15] to render the mantle plastic up to the present depth of isostatic compensation (roughly between 50 and 100 km.). Thus, the ocean depths d' appearing in Table 1 must be corrected for the presence of isostasy.

For precision in terminology, the Earth's crust will be defined as the region above the Mohorovičić discontinuity, and the solid region below will be referred to as the mantle. On the left (labelled 'present') in Fig. 1 are shown standard sections through the Earth's crust and mantle, for continental and ocean columns, as deduced by Worzel and Shurbet[16] by means of relatively accurate seismic data from explosions. The standard land column consists of 33 km. of crustal rock of density 2·84 overlaying mantle rock of density 3·27. The corresponding ocean column consists of 5 km. of sea water (density 1·03), 1 km. of sediments (density 2·30), and 4½ km. of crustal rock (density 2·84) over the mantle for a total depth of 10½ km. of crust. With these densities, the land and ocean columns are in isostatic equilibrium at a depth of 33 km., corresponding to the depth of the Mohorovičić discontinuity under the continents.

At the time of impact of the meteorites forming the ocean basins, the Mohorovičić discontinuity must have been level under the areas now corresponding to continents and oceans, as shown on the right (labelled 'pristine') in Fig. 1. Its depth must have been intermediate between the present depths of this discontinuity below the oceans and continents. Using the data of Kossinna for the total area of the Earth corresponding to continents (including marginal seas) and oceans, it can be computed from the volume balance that the level in question lay 14 km. above the present depth of this discontinuity under the continents, as shown in Fig. 1. The standard land and ocean sections above the Mohorovičić discontinuity appear superposed on this base-level (with the sedimentary layer omitted). The figure represents the proper relative position of the land and ocean columns immediately after meteorite impact, when anisostatic conditions prevailed, provided two conditions have been fulfilled. The first is that isostatic adjustment of oceans and continents, from pristine to present conditions, took place by horizontal flow of mantle rock at depths below the Mohorovičić discontinuity, as occurs in the isostatic balance of the present day. The second is that each standard column (land and ocean) above the Mohorovičić discontinuity has remained approximately the same throughout the Earth's history since the oceans were first formed. This assumption is reasonable in view of the small thickness and mass of oceanic sediments compared with the corresponding quantities for a total column, and implies that isostatic readjustment was fast compared with erosive processes.

On these assumptions, a first approximation to the mean depth $\bar{d}$ of the craters corresponding to the primordial ocean basins before isostatic adjustment is fixed approximately as the difference of the thickness of crustal rock in the standard continental and oceanic columns, with the sediment thickness ignored in the latter, as indicated in Fig. 1. This estimate can be improved in two respects. The first is to include in the estimate an additive correction for the ocean sediments, since primordially these deposits must have existed in the continental column. The present thickness (1 km.) of such sediments yields 2 km. for this correction, corresponding to the fact that the total area of the deep oceans is about twice that of the remainder of the Earth. Secondly, to take account of the fact that the depths of the lunar maria were reckoned from the approximate maximum heights of the rims[8], one can include 1 km. in $\bar{d}$ corresponding to the mean height (840 m.) of the continents. The resulting value of $\bar{d}$ is entered in Table 2 with a possible error of ± 10 per cent of its value. The mean height of rim $\bar{l}$ of the meteorite craters forming the primordial ocean basins can be obtained. Prior to the meteorite impact, the crustal rocks must have overlain the Mohorovičić discontinuity to an approximately uniform height L. The value of L can be computed directly from the present thicknesses of crustal rock under the continents (including marginal seas) and oceans, and the corresponding areas[12] on the surface of the Earth, as 15 km. The mean rim height $\bar{l}$ is then simply the difference of the height of the standard continental crustal column and L (the correction associated with the sediment thickness cancels approximately). The value of $\bar{l}$ appears in Table 2 with a possible error of ± 10 per cent of its value. The mean diameter D of

the craters corresponding to the primordial ocean basins, given in Table 2, was fixed from equation (1) with A taken as the mean area of a present ocean. These computations presume that a right circular cylinder represents a reasonable geometrical model for both the present and primordial ocean basins, and that isostatic adjustment leaves the diameter approximately the same.

Table 2. Mensuration of Average Primordial Ocean Basin (Anisostatic)

$\overline{D}$ (km.)	$\overline{d}$ (km.)	$\overline{l}$ (km.)	$\overline{r}$ (km.)
9,000	32 ± 3	18 ± 2	2,900

To find the depth and height of rim of an individual ocean basin under anisostatic conditions it will be assumed as an approximation that each basin was geometrically similar to the average basin, primordially. Thus, the anisostatic depth d corresponding to the diameter D is given by :

$$d = (\overline{d}/\overline{D})D \qquad (2)$$

and the anisostatic height of rim l is fixed by :

$$l = (\overline{l}/\overline{D})D \qquad (3)$$

These primordial dimensions are shown in Table 1 for each ocean, with a possible error of ±10 per cent of the value.

A sequence of events involving isostatic compensation, similar to that postulated here for the ocean basins, has been invoked by Daly[17] in explaining the Vredefort ring-structure of South Africa as the result of a meteorite impact. Harrison[19] recognizes the need to consider isostatic readjustment of the pristine ocean basins after meteorite impact, but he does not attempt a quantitative treatment, as carried out here. He considers the Pacific Ocean to arise from the fall of a single meteoritic body, whereas the more reasonable assumption that two impacts were responsible is made in the present work.

Correlations

Fig. 2 shows the correlations obtained between the diameter D and depth d for terrestrial explosion and meteoritic craters, on one hand, and lunar craters and circular maria, on the other[9]. The solid curves shown for craters on land represent the quadratic form :

$$D = a_1 d\,[1 + (d/a_2)] \qquad (4)$$

for hard and soft rock. The parameter a_1 was fixed from the dimensions of explosion craters[18] in basalt and sedimentary rock, while the corresponding a_2 was chosen by a least-squares fit to the dimensions of lunar craters[19] of Classes *IH* and *IS*, respectively. The craters of Class *IH*, lying in the highlands, and of Class *IS*, in the floors of the maria, correspond by inference to hard and soft rock, respectively. A close correlation exists between the data representative of terrestrial meteoritic craters in hard and soft rock, and the corresponding curves constructed from the dimensions of terrestrial explosion craters and the lunar craters in question.

The curves for craters formed in hard and soft rock under water correspond to the form :

$$D = a_1 d\,[1 + (d/a_2)^n] \qquad (5)$$

The coefficient a_1 for hard and soft rock was determined from the dimensions of craters, Glasstone (*H*) and Glasstone (*S*), respectively, formed by explosion of nuclear bombs in water[20]. This procedure presupposes that the parameter μ defined in terms of the depth of water δ by :

$$\mu = \delta/d \qquad (6)$$

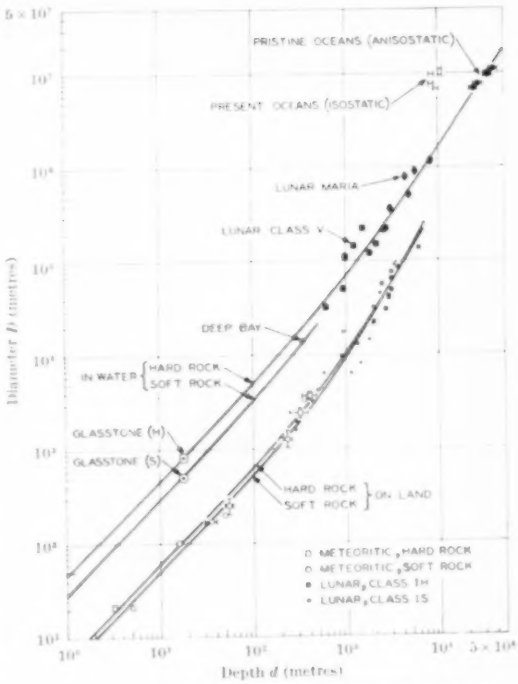

Fig. 2. Correlation of diameter versus depth for the present and pristine oceans, the lunar maria, and various classes of craters. The curves correspond to fitted functions for craters on land and in water, for hard and soft rock

have a value of the order of unity for a crater[9]. However, the resulting curves are approximately independent of the precise value of μ, so long as it is in the range $1/12 < \mu < 2$, roughly. For both hard and soft rock, the coefficient a_2 and exponent n correspond to a least-squares fit of the data for lunar craters[19] of Class V, which are the nine craters for which the representative points are displaced farthest from the curves for Class I in Fig. 2. The representative points for the lunar maria fall closely on the curve for craters formed in hard rock under water. The final link in the argument that the lunar maria are simply meteoritic craters formed in the presence of a hydrosphere is provided by the terrestrial meteoritic crater of Deep Bay[21]. It can be argued strongly that this crater must have been formed by impact of a meteorite in water, and the corresponding point lies close to the curve expected.

Prior to the impact of the meteorites forming the ocean basins, water must have covered the Earth to a uniform depth $\bar{\delta}$ above the roughly level surface of the crustal rock. On the assumption that the total volume of sea water has not changed greatly since the ocean basins were formed, the value of $\bar{\delta}$ is approximately 3 km. Accordingly, the parameter $\bar{\mu} = \bar{\delta}/\bar{d}$ corresponding to equation (6) had a value of roughly 1/11 for the crater corresponding

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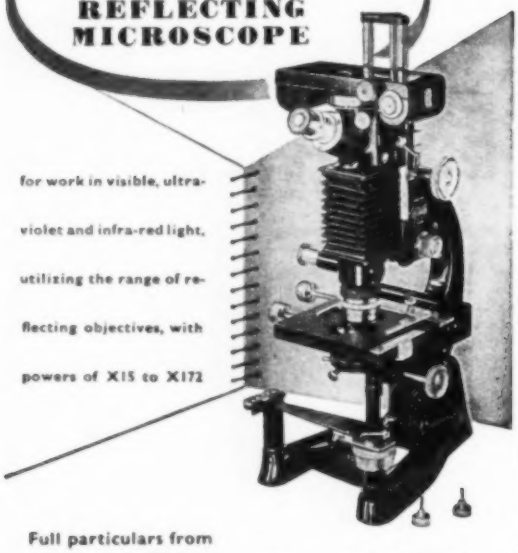

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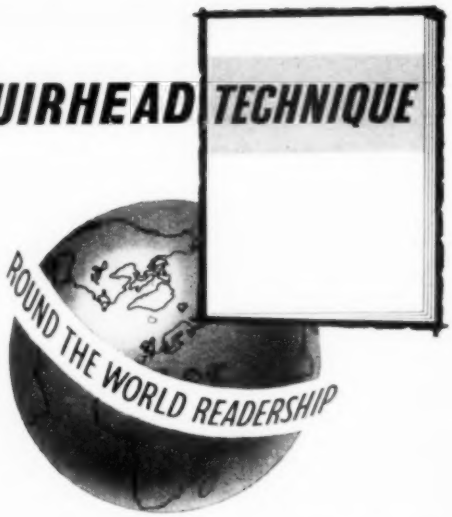

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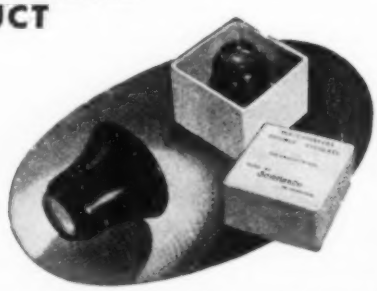

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to the average primordial ocean, and lies within the range for which the curves of Fig. 2 for craters in hard and soft rock under water apply. The diameter D, as a function of the anisostatic depth d for each primordial ocean basin, is plotted in Fig. 2 from the data of Table 1. The correlation of the points for these data with the curve for craters formed in hard rock under water is excellent, agreeing with the fact that the substratum of an ocean basin is basaltic. Furthermore, no data on the dimensions of the lunar maria or terrestrial oceans were used in the construction of the curve in question. On the other hand, the points corresponding to the diameter D and present depth d' of an ocean show agreement with the curve only within an order of magnitude.

One might argue that the excellent correlation of diameter and depth of crater obtained is fortuitous as regards the craters corresponding to the primordial oceans. To rule out this possibility, the correlation of diameter and height of rim will be examined. It will be assumed that the relation between the diameter D and height of rim l of a crater formed in water (for $\mu \approx 1$) can be written as the linear form:

$$D = b_1 l \qquad (7)$$

with the coefficient b_1 fixed in the cases of hard and soft rock by the dimensions of Glasstone (H) and Glasstone (S), respectively. The corresponding straight lines appear in Fig. 3.

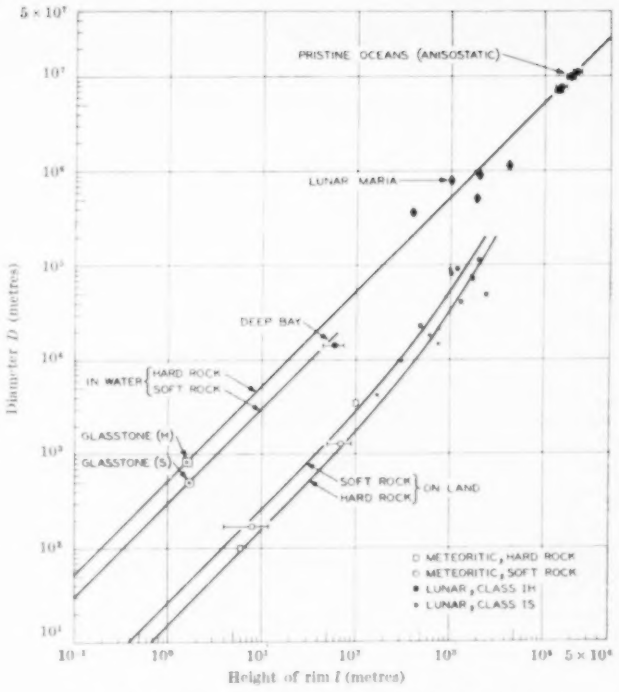

Fig. 3. Correlation of diameter versus height of rim for the pristine oceans, the lunar maria, and various classes of craters. The curves correspond to fitted functions for craters on land and in water, for hard and soft rock

For the lunar craters of Class V, only a few uncertain heights of rim are available for comparison with the result of the corresponding line for hard rock[19]. However, the heights of rim of the lunar maria can be approximated as the maximum heights of the encircling mountains less the mean height (2 km.) of the lunar highlands above the lowlands[9]. From Schmidt's results[22], this yields the representative points for the lunar maria shown in Fig. 3. The agreement of the points with the line for craters formed in hard rock under water clearly is good. Also shown are the diameters of the primordial ocean basins as a function of the anisostatic height of rim l, from Table 1. The correlation of the points with the line for craters formed in hard rock under water is excellent. Furthermore, the fitting line was determined completely from the dimensions of Glasstone (H). As a final argument, it may be noted that the representative point[23] for the terrestrial meteoritic crater of Deep Bay (formed in soft rock) lies reasonably well on the appropriate straight line.

Analogous curves for craters in hard and soft rock on land are shown also in Fig. 3. The two curves were determined from dimensions of explosion craters in basalt and sedimentary rock[18], and of lunar craters[19] in Classes $1H$ and $1S$, respectively. The correlation of the points for terrestrial meteoritic craters in hard and soft rock with the corresponding individual curves is not close, because of the sparsity and inaccuracy of the data. The general similarity of Fig. 2 and Fig. 3 is obvious.

In general, the correlation of the pristine dimensions of the terrestrial oceans with those of the lunar maria is excellent.

Origin of Continents

If the primordial ocean basins were large meteoritic craters, it follows that the primordial continents were simply structures corresponding to the rims of these craters. To see if the model is adequate quantitatively, one can calculate the average width of the rim of a crater corresponding to a primordial ocean. It will be assumed that the cross-section of the rim is a right triangle in the plane of the axis of symmetry of the crater, with the hypotenuse forming the outer slope and one side parallel and one perpendicular to the axis. The altitude of the triangle is the height of rim l, and the length of the base will be designated by r. The average value $\bar{r}$ of the base of the rim can be calculated from the data of Table 2 by invoking Schröter's rule[19,24] for lunar craters, that the volume of the material displaced from the crater equals the volume of the rim. This gives:

$$\bar{r} = (3/4)\bar{D}\,\{[1 + 4(\bar{d} - \bar{l})/3\,\bar{l}]^{1/3} - 1\} \qquad (8)$$

on these assumptions, and the average value of the base of the rim is entered in Table 2. It can be noted that Schröter's rule is a necessary consequence of explosive origin of a crater[25,26].

For the continents regarded as circular in plan, one can determine an average diameter from equation (1) by taking A as one-sixth of the total area of the

continents (considering Eurasia as a single continent). The corresponding average diameter is approximately 5,600 km. From the result of Table 2 for $\bar{r}$ it can be seen that two abutting rims from adjacent craters corresponding to primordial oceans yield an average width of 5,800 km. for a continent. Thus, the hypothesis is closely consistent with the mean linear dimension of a continent in plan, as observed.

At the time of formation, the primordial crater rims were mountains of lunar type, and not of the folded type characteristic of present terrestrial topography. Further, these primordial mountains were of about twice the height above the Earth observed to-day for the highest peak (Mount Everest). The eroded remnants of these mountains are the continental shields of crystalline igneous and metamorphic rock of Pre-Cambrian age, forming the nuclei of the continents. The view that the continental shields are simply the eroded roots of ancient mountain systems has been expressed by Collins[27] and Wahl[28], and seems to have gained general acceptance[29].

These ideas yield a direct and natural explanation of Wegener's law[30]. This law states that the frequency curve of elevation on the Earth shows two pronounced maxima, corresponding to the ocean floor and to the continents. On the thesis of the present article, one maximum arises from the floor-level of the craters forming the primordial oceans, and the other corresponds to the rims of the craters. During the time since these rims first reached continental level, the processes of erosion, deposition, and diastrophism have maintained a balance, to yield a roughly constant mean height of the continents. The possibility of explaining the law in question was a major inducement to Wegener in formulating his theory of floating continents.

Discussion and Conclusions

It is clear that the hypothesis proposed yields a direct explanation of the origin of ocean basins and continents. The correlation of the pristine dimensions inferred for the ocean basins with those for lunar features and terrestrial craters formed in water represents a strong argument for the general validity of the ideas. The disparity in the depths of the Mohorovičić discontinuity under continents and oceans appears directly as an essential element in the argument, without the need for *ad hoc* assumptions. Furthermore, the theory is consistent with the observed average diameter of a continent, and Wegener's law follows naturally.

The considerations of this article have an important bearing on the meteoritic impact theory of the formation of lunar craters. In the view of Baldwin[19], Urey[31] and Kuiper[32], the prevalence of craters formed by meteoritic impact on the Moon is not a feature peculiar to that body, but implies a similar bombardment of the Earth by meteorites in the past. However, the lunar craters obviously extend over a wide spectrum of sizes and ages. On the other hand, only 17 craters or clusters of craters were known at the time of Baldwin's work, and all these craters were small (of diameter less than 2 km.) by lunar standards and of recent geological age.

During the past decade, the situation has changed markedly. Discoveries of meteoritic craters in this period have enlarged significantly the total number known[9,33]. The age horizon has been extended to Early Palæozoic (Brent and Holleford Craters) and the size of crater to a diameter of about 14 km. (Deep Bay). Furthermore, the discovery of coesite in Barringer Crater[34] in Arizona and in the Rieskessel[35] in Austria has reinforced strongly the contention that crypto-explosive features[19,36] are in fact meteoritic in origin. If this view is accepted, the Vredefort structure[17] provides an example of a meteoritic crater which is roughly 130 km. in diameter and is Pre-Carboniferous in age. Finally, two large circular arcs have been noted in Canada, which may be meteoritic in origin[23], and one has a diameter of 400 km.

Since the meteorite impacts forming the ocean basins occurred far back in Pre-Cambrian times, it is implicit in my thesis that the bombardment of the Earth by meteorites has shown the same intensity throughout the ages as in the corresponding case of the Moon. At the present time, the Earth is experiencing merely the terminal phase of the process, marked by relatively sparse and small meteorites. In the past, the smaller craters on land vanished rapidly through erosion, sedimentation and diastrophism. The larger craters are relatively resistant to these processes; but another factor, isostatic readjustment, operates to make identification difficult, as in the cases of ocean basins and crypto-explosive formations. Only for craters formed by impact of large meteorites in the hydrosphere is there hope of preservation over an extended period of time, because of the protection afforded by the water from subaerial erosion. In view of the enhanced rate of sedimentation in the shallow seas close to a land mass, the chance of preservation increases with the depth of the water[37].

The primordial ocean basins were simply the largest meteoritic craters ever formed on the Earth, entirely analogous to the circular lunar maria. They owe their preservation to their size, in spite of the effects of isostatic readjustment, mountain growth, erosion, and sedimentation in masking the characteristic features of a meteoritic crater. Because of their extent, transcending that of any other hydrospheric features on the Earth, it has been possible here to correct their dimensions for isostatic readjustment in a simple manner. This particular method cannot be applied in the case of a marginal sea of the ocean; it is possible that many such seas are meteoritic in origin, but demonstration of the fact may be difficult in an individual case. A possible example is the arm of the Gulf of St. Lawrence, outlined by the coasts of Nova Scotia and New Brunswick[38]; the diameter is 300 km.

Ideas similar to mine and Harrison's[10] have been adumbrated by others. Chenoweth[39] has pointed out the close similarity between the Northern Canary Basin and Mare Crisium, and he has noted analogies in the features of the floor of the North Atlantic with structures in the basins of lunar maria. Gold[37] has speculated that the patterns of circular arcs in the zones of tectonic instability and gravity anomaly, and in regions of earthquakes and volcanoes on the Earth, may reflect the destruction of hydrostatically stratified balance by ancient meteorite impacts. A theory of Howell[1] bears a superficial resemblance to that presented here, but differs in that the meteoritic impacts considered are not explosive in nature. A full account of this work will appear elsewhere.

I thank E. W. Price and Dr. R. G. Greenler for discussions, and Helen Jackson for computational work.

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GALACTIC EXPLOSIONS AS SOURCES OF RADIO EMISSION

By Prof. G. R. BURBIDGE

Yerkes Observatory and Enrico Fermi Institute for Nuclear Studies, University of Chicago

The Problem of the Energy Sources

IT is generally believed that the major source of non-thermal radio emission, both inside and outside our Galaxy, is high-energy electrons and positrons moving in weak magnetic fields. The strongest non-thermal sources in our own Galaxy, such as the Crab and the Cassiopeia *A* source, are known, or thought, to be supernova remnants, and it is possible that the majority of the non-thermal radio-frequency radiation emitted has arisen directly or indirectly from supernovæ[1]. The strongest extragalactic sources are radiating at power-levels up to 10^7 times that of our Galaxy.

The most difficult problem associated with this mechanism of emission has always been the source of the energy now contained in the high-energy particles and magnetic field. The first idea as to the source of the energy came when Baade and Minkowski[2] suggested that the source Cygnus *A* was two galaxies in collision. This was followed up by the spectroscopic work of Minkowski[3] on the source identified as *NGC* 1275. He showed that there were two large-scale regions in the system with a large relative velocity between them. However, neither this result nor the somewhat more subjective argument that some sources look like galaxies in collision is conclusive, and fundamental objections have been raised to such an explanation. On one hand, Ambartsumian[4] has shown that the frequency of collisions of galaxies in the general field is too small to explain the observed numbers of radio sources. Secondly, the major theoretical argument in favour of the collision hypothesis is that the kinetic energy dissipated in the collision is converted to magnetic and particle energy. However, as has been pointed out by me[5,6] and by Shklovsky[7], this argument requires that, depending on the system being discussed, between 1 and 100 per cent of the energy available in the collision must be transferred into these energy modes. Since the transfer process appears to be very inefficient, such a requirement seems impossible to fulfil.

Other explanations for particular sources have been proposed. In analysing the results for *M* 87, I mentioned the possibility that the annihilation of a comparatively small amount of anti-matter could give the required energy in the form of electrons and positrons without any nucleon component[8]. This argument was applied more generally by Hoyle and me[9]; but, although such an idea still has its attractions, we have been faced by a fundamental difficulty concerning the origin of anti-matter and its separation from matter. I have considered a modified version of the collision hypothesis which would apply to clusters of galaxies[10]. This theory suffers from the objection that, though some radio sources lie in clusters, many new identifications by Bolton[11] and Mills[12] show that the majority do not. Finally, Hoyle[13] has given a new treatment of the problem, again using as a basic hypothesis the idea that, in the cases of Cygnus *A* and *NGC* 1275, the only strong extragalactic sources he discusses, collisions are the source of the energy.

Since this work was done, further evidence of the different types of galaxy which are abnormally strong radio emitters has come from optical identifications using the accurate positions obtained by the observers,

in particular Bolton and the California Institute of Technology group[11]. The least predictable of these results, in the light of any of the foregoing hypotheses, is the frequency with which many strong sources can be identified with single or double elliptical galaxies. The radio source which was the first system to be identified in this category, and which may be the prototype of this kind of source, is *M* 87. A number of others are listed by Bolton[11].

In what way do elliptical galaxies differ from other types in their general characteristics? First, it is believed that, on the average, they are more massive than either spiral or irregular galaxies. Secondly, they appear to contain very little gas and dust. Although the presence of the [O II] λ 3727 feature in about 30 per cent of all elliptical galaxies shows that some excited gas is present, detailed investigation in one or two cases[14] shows that there is very little gas—10^{-5}–10^{-8} of the mass—and that it is concentrated at the centre. Thirdly, studies of the luminosity distribution and the apparent sizes, together with mass estimates, suggest that elliptical galaxies are much denser than spiral galaxies.

Unquestionably, for sources such as this, the collision hypothesis can be ruled out, and it appears most probable that the sources of energy must lie in the stars in these galaxies. The only sources of energy which are adequate to explain the phenomenon in single galaxies are anti-matter, which was discussed earlier, rotational energy, and nuclear energy. Many of the elliptical galaxies probably have little rotation (*M* 87 is a spherical system) and even if they do, with very little gas spread throughout the galaxy, it would plainly be a very difficult matter to utilize such energy, so that nuclear energy is by far the most plausible origin. Shklovsky[7], in rejecting the collision hypothesis for other sources, has generalized the argument that supernovæ are the basic sources of energy for objects such as the Cygnus source and *NGC* 5128, both of which contain much gas, and also *M* 87. Without going into a critical appraisal of this latter work I would like to propose that supernovæ are also the sources of energy in all those elliptical galaxies which are strong radio emitters. In developing this hypothesis, we must bear in mind that the scanty spectroscopic data on objects of this type suggest that they do not differ noticeably from the majority of other elliptical galaxies in their stellar content.

The magnitude of the effect that we have to explain can be taken from the energy calculations that have been made for *M* 87 (ref. 8) and *NGC* 6166 (ref. 6), with these treated as typical examples. For *M* 87 it has been found that the minimum total energy for particles and magnetic field is of the order of 10^{58} ergs. In this galaxy the jet is due to visible acceleration or synchrotron radiation with electron and positron energies in the range 1–100 BeV., and magnetic fields in this region having strengths of the order of 10^{-3}–10^{-4} gauss. In all the other sources in this category, however, there is no component of optical radiation so far detected which can be due to accelerated particles. The minimum magnetic field strengths deduced are accordingly, for all these sources, not significantly larger than the fields which I believe to exist normally in the interstellar matter of our own Galaxy.

In a typical elliptical galaxy, in the central region, most of the light is contributed by *K* giants which are probably stars in the range of 1–1·5 $M_\odot$ that have evolved into the giant region of the Hertzsprung–Russell diagram. Evidence for this comes from the spectra[15,16] and the colours[17]. Much of the stellar content is, therefore, probably stars with masses $\lesssim 2\ M_\odot$.

In the normal course of evolution some stars in such a galaxy will eventually become supernovæ. Now supernovæ exploding at a rate of one every few hundred years per galaxy cannot provide the energy required for the strong sources to emit at the observed rates. This is easily shown as follows. The total energy in a radio source such as *M* 87 is $\sim 10^{58}$ ergs or the energy emitted by 10^7–10^8 supernovæ. In the normal course of events, this energy would be released by the nuclear explosions in a period of 10^9–10^{10} years. However, the time-scale for radio emission in such a source, which can be estimated from the energies of the electrons and the assumed strength of the magnetic field, is of the order of 10^7–10^8 years. Thus the reservoir of energy from the supernovæ would build up to only $\sim 10^{-2}$ of that required. For sources stronger than *M* 87, such as *NGC* 6166 or Cygnus *A*, this difficulty becomes even more severe since the normal time-scale would be $\sim 10^{11}$ years. What is needed here is a mechanism that gives rise to a large number of supernovæ explosions in a comparatively short time. The suggestion that I make, therefore, is that one supernova acts as a trigger to set off a chain reaction of stellar explosions. Is such a situation possible?

Let us review our knowledge of stellar densities in galaxies.

Density of Stars in Galaxies

In the centre of *M* 31, a spiral galaxy, there are some $1{\cdot}3 \times 10^7$ stars within a radius of 7·4 parsecs or a mean density of 1,700 $M_\odot$/parsec³ (ref. 18). In elliptical galaxies, the gradient of luminosity shows that the gradient in density is much steeper than it is for spirals. However, we have no way of estimating the star density at the very centre of an elliptical, that is, within about 1 parsec of the centre, since at the distance of the Virgo Cluster 1 parsec is approximately 0·01″, which is about two orders of magnitude below the seeing-limited resolving power of the largest land-based telescopes. The luminosity distribution and the velocity dispersion of the stars or gas in large elliptical galaxies such as *NGC* 3379[15] and *NGC* 4278[19] enables us to estimate the average density over a volume contained within a few seconds of the centre. If we take the results for *NGC* 4278 as an example, we find that a mass of $3 \times 10^8\ M_\odot$ is contained within a radius of 85 parsecs, or the average stellar density is 1,200/parsec³ in this volume. The results obtained by approximating the density curve for an isothermal gas sphere correspond to approximately the same density. However, it is possible that the mean density in the central region is considerably higher than this. Moreover, recent work on *M* 32 suggests that dwarf systems may be considerably denser than large elliptical galaxies. The mean density within the radius containing half of the mass of *M* 32 is 85 times that in *NGC* 3379. If the central density of *NGC* 3379 were about 1,200 stars/parsec³, similar to that in *NGC* 4278, then if the same model applies to all three galaxies the central density in *M* 32 is at least 100,000 stars/parsec³.

Let us suppose that the stellar density of the very centre of a galaxy is of the order of $10^7\ M_\odot$/parsec³. In this case, we might imagine that this density prevails over a radius of 1 parsec from the centre.

Under such conditions, application of the virial theorem shows that the velocity dispersion of the stars is about 400 km./sec. This is comparable with, or less than, the velocity dispersion of the stars in the larger bulk of the nucleus, which lies in the range 400–800 km./sec. Since such a tiny central condensation cannot be observed directly and since its contribution to the integrated light of the nucleus, of radius a few seconds, is negligible, it cannot be said that such a feature could not exist. The formation of a star cluster out of gas ejected from earlier generations of evolving stars, the gas dissipating much of its kinetic energy before stars form, makes such a system possible.

In such a dense region the probability of stellar collisions is quite high. This point has earlier been made by Shklovsky[7]. If such a stellar collision leads to a stellar explosion (and this may well be the case), this will itself provide the trigger instead of a normal supernova explosion which I shall discuss next. However, much depends on how such a dense central condensation forms and whether or not it is a physically separate entity, that is, whether the amplitudes of the orbits of the stars are less than the dimension assumed for it.

It seems fair to conclude that a reasonable extrapolation of the observations suggests that the central densities in elliptical galaxies range upward from 10^3 stars/parsec^3 to values in excess of 10^5 stars/parsec^3. Furthermore, we may speculate that densities in the range 10^6–10^7 stars/parsec^3 may be present in some cases.

It is interesting that Greenstein[19] has suggested that one of the elliptical galaxies in the pair *NGC* 4782, 4783, which is a radio source, is more centrally condensed than is the usual case. Direct plates recently taken by E. M. Burbidge at the prime focus of the 120-in. telescope of the Lick Observatory show that the nucleus of one member of the pair is much more highly condensed than the other.

Supernova Explosions

It is likely that for stars of masses not much greater than the Sun, supernova outbursts will not be of the implosion–explosion type[20], but will stem from the explosion of degenerate material in the way proposed by Hoyle and Fowler[21]. The total energy that is released in such explosions is of the order of 10^{50}–10^{51} ergs.

Energy is ejected from a supernova in γ-radiation, X-radiation, and high- and low-energy charged particles. The amount of degradation of the radiation by the supernova material itself is not known. However, it is reasonable to suppose that a considerable fraction will escape as fairly hard radiation. The comparatively small amount of visible radiation in known supernovæ, as against the total amount of nuclear energy available for release, would also suggest this. When incident on the surface of a nearby star, the major amount of the energy which is carried in γ-radiation will be scattered and absorbed. The total absorption for energies of a few MeV. will be of the order of a few grams. This corresponds to a penetration in a giant, according to the tables of Schwarzschild, of the order of 10^4–10^6 cm. in the convective zone, that is, the top of the convective zone. In a normal solar-type star it represents penetration of only a few metres or perhaps penetration to just below the bottom of the atmosphere. The low-energy charged particles will presumably be stopped from penetrating by the star's magnetic field. The high-energy particles will penetrate considerably farther than the γ-radiation.

If a flux of energy E ergs is emitted in the first supernova explosion then the energy incident on the surface of a star D cm. away will be $E/4\pi D^2$, and the energy absorbed per gram if the radiation passes through x gm. before being absorbed is $E/4\pi D^2 x$. For values of D ranging from 3×10^{17} cm. to 10^{18} cm. and E equal to 10^{50}–10^{51} ergs, with $x \simeq 5$, we find that the temperature of the surface layers of the star will be raised to values from 10^5 to 10^9 degrees.

If the material is heated to values in the upper part of this temperature-range, that is, 10^7–10^8 degrees, nuclear reactions will abruptly commence. The reactions that can occur will depend on the composition of the material present. The most probable reactions will be those involving carbon, nitrogen, oxygen and hydrogen. It appears that what we have here is the generation of a detonation wave which will, in suitable circumstances, be propagated into the interior. Without extensive numerical work it is not possible to determine how the propagation will go. Two effects have to be considered. The first is that the wave must be propagated into regions of higher density, and second, the geometry is such that there will be a focusing effect towards the centre of the star. A sudden generation of energy as the wave passes through the star will lead to explosion. The violence of this will depend on the type of star on which the radiation impinges. The problem is somewhat similar to that encountered by experimenters who are trying to generate thermonuclear reactions in a hot plasma. In their case, some of the limitation on the generation of thermonuclear power is the rate of loss of energy by bremsstrahlung processes and the confining of the plasma. However, in this case the back-scattered radiation may be lost or may simply heat the atmosphere so that it expands, but the forward-scattered radiation will be absorbed further in the star, thus causing pre-heating before the detonation front passes.

If such a chain reaction of stellar explosions occurs, the nucleus of a galaxy will slowly brighten. The rate at which it will brighten is determined by the separation of the stars and the rate at which the light from individual supernovæ fades. Suppose that the radius of the volume over which the event occurs is about 50 parsecs, then the time taken for the whole event to occur will be about 150 years. It will be a little greater than the time for radiation to travel through this volume since a finite time is needed for each star to explode after it is irradiated. The brightening of the galaxy will be very considerable, the maximum being reached just at the point at which the density of stars begins to fall off rapidly. It is this drop in density that will stop the chain reaction. The brightening may amount to something of the order of 10 mag. or greater. However, it is not clear whether such radiation will appear in the normal photographic region of the spectrum, for the following reason.

When such an event occurs, the first supernovæ will brighten the galaxy in a normal fashion, the original radiation being emitted. After a considerable amount of gas has been ejected, however, succeeding supernovæ will irradiate this gas. It will become ionized and will achieve a temperature near 10,000°. It will also have a high random velocity since the gas is ejected from the supernovæ at several thousand kilometres a second. In such a situation all the forbidden lines excited in nova shells will appear. Such a situation is reminiscent of what we

see in some of the abnormal radio sources such as Cygnus *A*, 3*C*-295, *NGC* 1275, and *NGC* 1068. Very strong emission features such as [O II] λ 3727, [N II] λλ 6548, 6583, *Hα*, [O III] λλ 4959, 5007, [Ne V] λ 3426, etc., will appear. A very large amount of energy will also be emitted in Lyman α. There are, therefore, several stages in the evolution of such a model. In the first stage, the galaxy will apparently brighten in its nuclear region. In the second stage, very strong emission lines excited by electron collisions and high random velocities will appear. In the third stage, the random velocities of the gas will die down and eventually all the gas will disappear since it has velocities considerably in excess of the escape velocity of the galaxy. Throughout all this time the radio emission is increasing in intensity and the high-energy particles are diffusing out through the galaxy. It seems probable that the supernovae give rise to the high-energy particles which move into the regions already containing some magnetic field, where they radiate. Finally, all evidence in the spectra of the explosion will have disappeared and only the radio emission will remain.

It appears that, if the nuclear regions of galaxies explode in the way indicated, they will also be strong sources of cosmic radiation. A very powerful mechanism for acceleration of particles is indicated. Consider, for example, two supernovæ which explode a few weeks or days apart. Many of the particles ejected with the first supernova shell will have a velocity much greater than that of the main body of the material in the shell and will therefore travel ahead of it. However, these particles will very soon collide with the expanding shell from the second supernova and be reflected. A large number of particles can, by this mechanism, be trapped between two supernova shells. At each reflexion they will gain energy in the way first suggested by Fermi. The energy gained through such a mechanism is enormous for particles with the right trajectories.

Conclusions

Although galaxies such as *NGC* 1068 and *NGC* 1275 can be seen to be spirals it is tempting to suppose that the same basic mechanism is operating here as is the case for the radio sources associated with elliptical galaxies. In spiral systems it is possible that there are regions where the star density is very high. Moreover, the more massive supernovæ which may be expected in such galaxies will release more energy and thus make the process more efficient. On the basis of this discussion we may tentatively classify some of the identified radio sources in an evolutionary sequence as follows:

First stage: *NGC* 1068, 1275.

Second stage: Cygnus *A*, 3*C*-295.

Third stage: *M* 87, *NGC* 6166, *NGC* 4782–83 and other elliptical galaxies.

Following Bolton[22] we may suppose that *NGC* 5128 is a system in which such an explosion has occurred more than once.

I have described earlier results which suggest that high stellar densities may be present in dwarf galaxies. Let us suppose that a chain-reaction of explosions occurs in a galaxy with the characteristics of *M* 32, but at a distance corresponding to a red-shift of 100,000 km./sec. At this distance the apparent magnitude of *M* 32 would be + 25·5, below the limit of any available optical telescope. Brightening of this galaxy by explosion would bring it well above the limit of observation. However, after the supernova phase has ended the galaxy will fade again but will remain a powerful radio source. Such a phenomenon could account for many of the sources which are apparently not identified with optical galaxies.

If the model outlined here is found to be acceptable, a number of general conclusions can be made.

(1) Strong radio sources will be produced in galaxies where the star density is high. They will not necessarily always occur in the most massive galaxies, but can occur in dwarfs also. The production of a strong source is a chance event since it requires that a star become a supernova while it is in a region of high density.

(2) Elliptical galaxies which are strong sources are comparatively old when this occurs. This is because a star of solar type needs $10–20 \times 10^9$ years to evolve before it becomes a supernova and triggers a galactic explosion.

(3) Sources which cannot be identified with optical objects may be at great distances. Alternatively they may be centred on dwarf galaxies the nuclei of which have exploded but which now are below the detection limit of the largest optical telescopes.

(4) If strong emission lines are present in identified sources this suggests that the explosion occurred comparatively recently. Since the time-scale for brightening or fading at this period may be only hundreds or thousands of years, a programme of investigation of the optical brightnesses and spectra of such sources should be undertaken, since secular changes may be detectable. Shklovsky[7] has already suggested that such changes be looked for in *M* 87.

There is some tendency for radio sources to be identified with pairs of elliptical galaxies or with galaxies with multiple nuclei. On this picture I must conclude that there is a tendency for the components of such systems to have abnormally high stellar densities.

I am indebted to Dr. E. M. Burbidge for a number of helpful discussions. A more detailed account of these ideas will be published elsewhere.

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OBITUARIES

Dr. J. Unrau

On March 2, 1961, with tragic suddenness, the death of Dr. John Unrau took one of Canada's outstanding geneticists and brought to an end a distinguished career of scientific accomplishment and leadership. Dr. Unrau's death, at the peak of his many challenging scientific activities, is mourned by his colleagues and friends in Canada and throughout the world.

John Unrau was born on January 24, 1916, at Karaguy, Orenburgski Territory, Russia. At the age of ten he moved with his family to Saskatchewan, where he obtained his early education in Mayfair and his high-school courses by correspondence. He entered the University of Saskatchewan and graduated with honours in field husbandry in 1942. In the same year he began graduate studies in genetics and plant breeding and obtained a Master degree in 1945. He then went on to Washington State University, where he undertook studies on wheat genetics under Dr. S. P. Swenson and the late Dr. Luther Smith, and received the Ph.D. degree in 1949.

In 1940, he married Mary Klassen of Mayfair. He is survived by his wife, a daughter, Mary Ann, and three sons, John, Paul and Phillip. John and Paul are students at the University of Alberta.

John Unrau's earliest research was in sunflower breeding at the Forage Crops Laboratory, Saskatoon. This study led to the development of the single-cross hybrid, 'Advance', still widely grown commercially. At Washington State University, he entered into the activities of the Department of Agronomy, and a start was made on his now well-recognized work on monosomic–nullisomic wheat. These studies of F_2 and F_3 crosses between common hexaploid wheats and Sears' chromosome-deficient series, in which he was able to associate specific genes with specific chromosomes, laid the foundation for his latter contributions to cereal genetics.

Dr. Unrau joined the staff of the University of Alberta in 1949 and became head of the Department of Plant Science in 1951. In addition to his intense research activity, he assumed a heavy teaching load and directed the research programmes of nineteen advanced graduates, many of whom have already achieved positions of responsibility and are now making significant contributions to the advancement of plant genetics in Canada. He gave much thought to, and took an active interest in, problems of university teaching and high standards of training. He participated in numerous university committees, and took an active part, as a member of the Prairie Regional Committee of the National Research Council of Canada, in the Associate Committee on Plant Breeding and the Sub-Committees of Common and Durum Wheats, Winter Wheat and Rye, and Cytogenetic Research on Cereals and Related Grasses. At the time of his death he was a member of the Honorary Advisory Council of the National Research Council of Canada and chairman of the Associate Committee on Radiation Biology.

The contributions John Unrau made to genetical research during his short professional career were numerous, leaving a lasting impact on geneticists, plant breeders and cereal cytologists alike. He was a recognized world leader in the exploitation of wheat monosomics and their use in determining gene-effects and linkage-relationships. He demonstrated that substitution lines of whole chromosomes could be used effectively to study the expression and control of quantitative characters. By the development of reciprocal substitution lines he showed that two varieties with contrasting characters could be used in precise genetic studies of character differences. While at the University of Cambridge, during 1957–58, his work led to new evidence on the origin of the *B* genome in wheat. His work on rust-resistant, soft-white, spring wheat culminated in the licensing of the important commercial variety, 'Kenhi', in 1958.

The Genetics Society of Canada owes a very profound debt to John Unrau; to the present membership he will long be remembered. His initiative, persevering and vigorous leadership were of utmost importance in launching the Society. His wise counsel and active part in soliciting support was decisive in establishing the *Canadian Journal of Genetics and Cytology*. He was a charter member and past director of the Genetics Society of Canada. Successively as vice-president, president and past-president, the Society was indeed privileged to have his outstanding leadership until the time of his death.

John Unrau's research output of some twenty-six articles is an impressive testimony to his rather brief but intensely energetic period of scientific activity. His monument will be his published papers and the men he has trained to add to his personal contributions in genetics. The memory of his life will remain with his colleagues and fellow members of the Genetics Society of Canada as an inspiring example.

T. J. Arnason
L. P. V. Johnson
W. J. White
A. Wilkes

Prof. B. J. Krijgsman

Prof. B. J. Krijgsman, who was head of the Sub-department of General Physiology at the University of Cape Town, died on April 17 at the age of sixty. At the time of his death he was also acting head of the Zoology Department. He had suffered from an incurable complaint of the lungs for some years, but such was his courage and strength of will that he rose above all adversity to remain an active scientist and teacher to within a week of his death. To the very end he maintained a deep humility and sense of responsibility towards his students and colleagues, always managing to find the time and energy to give friendly advice or offer gentle criticism. Though a prolific research worker, Prof. Krijgsman was a man of exceptionally wide interests. He was a great reader, particularly favouring philosophical topics, and was very interested in art. However, his main form of relaxation was listening to music or, when his health allowed, playing the piano, on which he was an accomplished performer. It was indeed as great a privilege to know him socially as it was to work with him in the laboratory.

Prof. Krijgsman was born in Holland in 1901. After studying biology at the University of Utrecht, he became junior lecturer there in 1921, later being appointed lecturer. In 1928, after being awarded the degree of doctor of philosophy with distinction, he emigrated to Java to become head of the Veterinary Research Institute at Buitenzorg. He later combined this post with that of professor of medical zoology at Batavia. In 1935 he returned to Holland to study the physiological effects of insecticides for the Netherlands Council for Scientific and Industrial Research and to lecture at the University of Utrecht. In 1949 he accepted the post of senior lecturer in physiology, in the Zoology Department, University of Cape Town, later being appointed associate professor. At the beginning of 1959 he became the first head of the newly formed Sub-department of General Physiology.

In spite of heavy teaching duties, Prof. Krijgsman published at least one hundred and twelve original papers during his lifetime, wrote four books on zoology and contributed to six others. His wife, Mrs. Nel E. Krijgsman, was a great help to him in this respect, being not only a devoted companion but also undertaking duties as his research assistant. Prof. Krijgsman is, perhaps, best known for his studies on the physiology of the invertebrate heart and on the physiology of parasites, but, in fact, he pioneered research in many fields, and the whole subject of invertebrate physiology would have been the poorer had he turned his talents elsewhere. The world of science has lost an eminent research worker and an original thinker: the University of Cape Town has lost also a valued colleague and friend.

A. C. BROWN

Dr. E. de Barry Barnett

EDWARD DE BARRY BARNETT, who died on March 23, will be greatly missed by his many former colleagues and students. He could truly be described as a character. He was held in great affection but was often unpredictable. His instructions to his executors were definitely that he did not wish any obituary notice to be published, but he left a summary of his life among his papers, realizing, no doubt, that it would not be possible to avoid such notice and desiring, as always, to be of help.

He was born on October 20, 1886, and educated at Malvern College and University College, London, graduating with first-class honours in chemistry in 1908. After holding some industrial appointments in the dyestuff and explosives industries, he went back to academic work and was appointed lecturer in organic chemistry at the Sir John Cass Technical Institute in 1919; eventually he became head of the Department and deputy principal, retiring in 1947.

He was the author of a number of well-known books, the latest of which, *Mechanism of Organic Chemical Reactions*, was published in 1956.

His own summary of his life passes very lightly over much that was significant. It does not tell of the extent or the high quality of his published papers, numbering more than a hundred, chiefly in the field of anthracene chemistry. It does not indicate his rather lonely private life as a bachelor, isolated by his deafness in so many ways. It gives no idea of the extent of his help to his students. He had an uncanny knack of selecting as junior laboratory staff those applicants who had the ability to advance. Barnett would teach them himself, at the same time often arranging and paying privately for other tuition to make good defects in their earlier education. Having got them over these hurdles, he would see that they lacked no help in gaining their degrees. There is no way of assessing the generous financial assistance that Barnett gave to so many students in days when grants from public funds were less common than they are now.

He was greatly handicapped by his deafness. His well-known "What?" with his hand cupped to his ear and his "You see what I mean to say", said in the loudest of tones, without any basis for uncertainty and not infrequently to the discomfort of those who overheard his criticism of them, remain as vivid memories. But at all these times, even when he criticized both his students and those in authority, there was a humorous twinkle in his eye and an underlying kindness in all he did.

Sir John Cass College was to him a life-time interest. He worked selflessly for its development throughout the whole of his teaching career. During the War, when much of the building was severely damaged by bombing and fire, he continued his teaching there, chiefly with classes at week-ends and by correspondence. He took more than his full share of fire-watching, spending his nights on the roof to make sure that his deafness did not cause him to miss any incidents that might have escaped his immediate attention had he been in a less-exposed position.

He is remembered by his many friends with a deep sense of loss and also with appreciation of the contribution he made not only to the advancement of chemistry but also to the development of the 'Cass'. His sincere care for the well-being and interests of his many students will not be forgotten.

A. M. WARD

Mr. W. E. Lawrence

THE death on April 16 of Mr. W. E. Lawrence came as a great shock to his many friends and admirers who have, from time to time, received his help and been regaled with his varied experiences during his forty-three years of service in the Prosectorium of the Zoological Society of London.

William Edward Lawrence was born May 1, 1900, the son of a London milk-roundsman; his mother was Welsh, but "Billy", as he was affectionately known, was himself—both in physical appearance and temperament—a typical Cockney, with his ready wit, quick repartee, irrepressive sense of humour and rich fund of experiences.

Lawrence received an elementary school education at Princess Road School, Regent's Park (1904–14). Here he proved a good scholar, reaching the highest standard. Under the influence of his teacher, a Mr. Dakin, a Zoo addict, Lawrence's interests were early channelled towards animals and he made many visits with his teacher to the neighbouring Zoological Gardens. Apparently it was through Dakin's influence that "Billy" was recommended to the post in the Society's Gardens when, as was customary at that time, he left school at the age of fourteen.

He entered the 'dead house', as it was then called, as prosector's boy and was placed under the direction of the prosector's assistant, Mr. C. H. Hicks, from whom Billy learned dissection, injection and the preparation of skeletal material, albeit employed mainly on menial tasks until Hicks' promotion to superintendent's assistant in 1925, when Lawrence

assumed charge of the technical aspect of the work in the Prosectorium. Apart from a brief interlude of two months in 1916 and two years war service (1917–19), he spent his working life at the Zoo, where he returned in 1920, first for a year as butcher's assistant and thereafter in the Prosectorium, where he remained until retiring on pension on October 1, 1958.

Lawrence's long service was officially recognized by his award in 1953 of the British Empire Medal in the Coronation Honours List, and in 1960 by the conferring of the Zoological Society's Bronze Medal.

One of his most outstanding memories dated from the epidemic in 1926–27 of anthrax in the Zoo's Elephant House. In January 1927, after an autopsy on an elephant, Lawrence developed two small malignant pustules which proved to contain the anthrax bacillus. He was rushed to hospital expecting to be dead in forty-eight hours, but in a few weeks he was back at work, cheerful as ever.

He leaves a widow, son and daughter, to whom the sympathy of his many friends and admirers will be extended in their recent bereavement.

W. C. Osman Hill

NEWS and VIEWS

The Queen's Birthday Honours List

The following names of scientists and others associated with scientific work appear in the Queen's Birthday honours list:

K.C.M.G.: Dr. John C. R. Buchanan, medical adviser to the Secretary of State for the Colonies; Dr. Boris P. Uvarov, lately director, Anti-Locust Research Centre.

Knights: Prof. John F. Baker, professor of mechanical sciences and head of the Department of Engineering, University of Cambridge; Robert R. Blackwood, general manager, Dunlop Rubber Co. (Australia), for services to the University of Melbourne; G. Trenchard Cox, director, Victoria and Albert Museum; Arthur B. Duncan, lately chairman, Nature Conservancy; Prof. Austin Bradford Hill, professor of medical statistics, London School of Hygiene and Tropical Medicine, University of London; Dr. Thomas Malcolm Knox, principal, University of St. Andrews.

C.B.: Dr. R. C. Sutcliffe, chief scientific officer, Meteorological Office, Air Ministry.

C.M.G.: G. C. L. Clark, president of the Australian Institute of Mining and Metallurgy; A. B. Cowen, deputy chairman, Standards Association of Rhodesia and Nyasaland; A. F. MacKenzie, Federal agricultural adviser, West Indies; Dr. J. O. Poynton, director of the Institute of Medical and Veterinary Science, State of South Australia.

C.B.E.: R. E. Beales, deputy director, Central Statistical Office, Cabinet Office; Dr. D. Curran, senior psychiatrist, St. George's Hospital, London; A. K. Briant, director of agriculture, Zanzibar; Dr. W. L. Francis, director (grants and information), Headquarters, Department of Scientific and Industrial Research; Dr. J. W. Gregor, director, Scottish Society for Research in Plant Breeding; Prof. J. E. Harris, professor of zoology, University of Bristol; A. J. Nicholson, formerly chairman, Division of Entomology, Commonwealth Scientific and Industrial Research Organization, Australia; L. F. C. Northcott, principal superintendent, Materials and Explosives Division, Armament Research and Development Establishment, War Office; E. Norton, research director, Yarrow and Co., Ltd., Glasgow; J. D. Parsons, director, Royal Ordnance Factories (Explosives), War Office; Dr. W. H. Penley, deputy chief scientific officer, Royal Radar Establishment, Ministry of Aviation; H. W. Springer, registrar, University College of the West Indies; A. B. Taylor, registrar-general, Scotland; G. A. Whipple, chairman and managing director, Hilger and Watts, Ltd.; R. G. McK. Willan, chief conservator of forests, Nyasaland; Prof. F. C. Williams, professor of electrical engineering, University of Manchester.

I.S.O.: T. W. V. Jones, senior principal scientific officer, Air Ministry (Bracknell, Berks.); A. D. Fraser, director of Wild Life Conservation, Southern Rhodesia; P. Ryan, director of agriculture, State of Victoria; J. H. Griffiths, chief electrical and mechanical engineer, Tanganyika.

Taxonomic Botany at Birmingham: Prof. J. G. Hawkes

At a time when it is becoming widely acknowledged that there is a shortage of scientifically trained taxonomic botanists, the election of Dr. J. G. Hawkes to a chair of taxonomic botany in the Department of Botany, University of Birmingham, is a noteworthy event. Dr. Hawkes was educated at Cheltenham Grammar School and Christ's College, Cambridge. After initial research training in cytology, he joined an Imperial Agricultural Bureaux expedition to South America as taxonomic botanist, and was appointed afterwards by the Bureaux to work out the taxonomy and cytogenetics of the potato material collected on the expedition. This was the beginning of the work which has made Dr. Hawkes a world authority on *Solanum*, commanding a unique knowledge of the distribution, variation and ecology of the genus in its principal areas in the New World. In addition to leading further expeditions in Central and South America, the last in 1958, he spent two extensive periods in Colombia at the invitation of the Colombian Government organizing a national potato research programme and training groups of specialists in various aspects of breeding and pathology. Since his appointment as lecturer in flowering-plant taxonomy at the University of Birmingham in 1952, Dr. Hawkes has combined his researches on *Solanum* with a study of the Warwickshire flora. Based on new methods of recording distributional data, this may well become a model of its kind. To his chair of taxonomic botany—the first in Britain to bear the name—Dr. Hawkes thus brings the admirable combination of first-hand acquaintance with tropical and temperate floras and the experience gained from the detailed study of a major genus by modern methods.

A Pioneer of Aerology: Prof. Vilho Väisälä

Modern weather forecasting techniques are largely based on observations derived from radio-sonde soundings. The name of Väisälä is known to all

meteorologists as that of an outstanding pioneer of the radio-sonde. Väisälä's association with aerology goes back to 1916 when he was appointed head of the kite station at Ilmala, Finland. In 1919 he became head of the aerological section of the Finnish Central Meteorological Office. After making a number of improvements to the earlier aerological observing methods he began to experiment with the Väisälä radio-sonde in 1931. This reached a stage of development which could be called entirely satisfactory by 1936. In 1944 Väisälä founded a company for manufacturing radio-sondes on a commercial scale, and at present it exports them to fifteen countries. But apart from his aerological activities Väisälä has pursued an active academic career, having been a teaching assistant and lecturer in meteorology at the Finnish Institute of Physics, and culminating in a personal extraordinary professorship in meteorology at the University of Helsinki, from which he retired in 1958 at the age of sixty-nine. It is announced in the journal of the Geophysical Society of Finland, *Geophysica* (8. No. 1; 1960), that, in order to commemorate the seventieth birthday of this outstanding Finnish scientist, the Society has struck a special medal with the inscription: "The Finnish Pioneer of Aerology".

National Institute of Industrial Psychology : Dr. R. B. Buzzard

Dr. R. B. Buzzard has been appointed research director of the National Institute of Industrial Psychology. The Institute's programme of research is partly financed by grants from the Department of Scientific and Industrial Research. After graduating in physiology and qualifying in medicine, Dr. Buzzard spent ten years as a member of the Medical Research Council's scientific staff at the Experimental Psychology Laboratory in Cambridge and then, in 1953, transferred to the Council's Industrial Psychology Research Unit at University College, London. His work has been concerned with problems of research and application in industry and the armed services. They have included training interviewers, the development of personnel-selection procedures, refresher training of returned prisoners of war, and investigations into industrial injury, sickness and absence and the effects of working environments. He will bring to the Institute wide experience of investigation in fields where the gap between research and practice in industry tends to be greatest. In 1960, he was awarded the Institute's Vernon Prize, which is given in alternate years to the investigator regarded as having carried out the most valuable research in industrial psychology and physiology.

C-E-I-R, Ltd.: Prof. M. G. Kendall

Prof. M. G. Kendall is to join the Board of C-E-I-R (U.K.), Ltd., the computer research services organization. He will be responsible for the Departments of Mathematics, of Statistics and of Operational Research. He will work closely with Dr. Alexander S. Douglas, the director of technical services, whose divisional responsibilities include Departments of Computer Services, of Computer Technology and of Programming. Prof. Kendall is at present professor of statistics in the University of London (London School of Economics) and will vacate his chair on September 30. He received his mathematical training at the University of Cambridge, and entered the Administrative Class of the British Civil Service in 1930 to work in what was then th Ministry of Agriculture and Fisheries, becoming the head of the Economics Intelligence Branch. In 1940 he resigned from the Civil Service to become statistician to the Chamber of Shipping of the United Kingdom. He remained at the Chamber of Shipping until 1949, becoming joint assistant general manager in 1947. Since leaving the Chamber of Shipping in 1949, Dr. Kendall has been professor of statistics in the University of London. Among his activities in the University and at the London School of Economics have been the creation and direction of the Division of Research Techniques. Its work in statistics, econometrics, social surveys, and in operational research is known and followed in every country of the world.

Euratom : U.K. Nuclear Energy Attaché

Mr. G. H. Greenhalgh, of the United Kingdom Atomic Energy Authority, has been appointed nuclear energy attaché to the United Kingdom Delegation to the European Communities, to succeed Mr. D. H. Hill. He will be taking up his appointment in the near future. Mr. Greenhalgh, who is forty and a chemist by profession, was a member of the Extra-Mural Research Division at the Atomic Energy Research Establishment, Harwell, until 1956, when he was appointed scientific attaché to the British Embassy in Stockholm. In his new appointment, Mr. Greenhalgh will act as adviser on nuclear energy matters to the Head of the United Kingdom Delegation to the European Communities and will keep in touch with the various installations on the territory of the Community concerned with the peaceful uses of nuclear energy. The present nuclear energy attaché, Mr. Hill, will be leaving Brussels at the end of May to take up a post with the Authority's Reactor Group.

Co-ordination of Research and Development of Sources of Energy

In a written answer in the House of Commons on May 16, the Minister of Power, Mr. R. Wood, said that his Advisory Council on Research and Development existed to co-ordinate research and development in the whole field of energy. Its terms of reference were: to advise the Minister on research and development in relation to his statutory duty of securing the effective and co-ordinated development of coal, petroleum and other sources of fuel and power in Great Britain, and of promoting economy and efficiency in the supply, distribution, use and consumption of fuel and power; to advise the Minister of new scientific and technical knowledge or application of knowledge which, in the Council's opinion, should be taken into account in the performance of his statutory duties; and to keep the whole field of fuel and power under continuous review with the object of identifying problems needing research and development and advising the Minister of those problems with the view of discussion with the industries concerned.

The members of the Council are: Lord Fleck (*chairman*); Capt. (E.) W. Gregson (*deputy chairman*); Mr. M. A. L. Banks, British Petroleum Co.; Dr. C. M. Cawley, Ministry of Power; Mr. T. B. Clark, Imperial Chemical Industries, Ltd.; Sir Josiah Eccles, Electricity Council; Mr. W. K. Hutchison, Gas Council; Dr. W. A. Macfarlane, National Industrial Fuel Efficiency Service; Sir Harry Melville, Department of Scientific and Industrial Research; Mr. L. Rotherham, Central Electricity Generating

Board: Prof. M. W. Thring, University of Sheffield; Dr. F. A. Vick, Atomic Energy Research Establishment, Harwell; Mr. A. H. A. Wynn, National Coal Board.

Programme of Sounding Rockets

In reply to a question in the House of Commons on May 30, the Parliamentary Secretary for Science, Mr. D. Freeth, said that the experiments in the present sounding rocket programme are devised by United Kingdom scientists and carried out in *Skylark* rockets fired at Woomera under joint Anglo-Australian arrangements. Provision of the rockets, the main element in the cost, is estimated at about £225,000 in the current year. The possibility of enlarging this programme in co-operation with the Commonwealth and Europe is under consideration, and a co-operative sounding rocket programme is one of the first questions which is being explored by the Preparatory Commission set up to plan a possible European organization for space research. The cost could not be assessed pending the outcome of the international discussions now in progress on the co-operative development of a satellite launcher, and on the scale of activities to be carried out by the proposed European Space Research Organization.

Population Statistics in England and Wales

The second part of the *Registrar General's Statistical Review of England and Wales for the Year* 1959 has just been issued (Part 2: Tables, Population. Pp. xi + 181. London: H.M.S.O., 1960. 11*s.* 6*d.* net.). There are no major changes in the presentation of the data, or the field covered, which includes population movement, births, marriages, marriage dissolution, fertility and statistics of electoral divisions and local elections. The estimated mid-year population for England and Wales was 45½ millions, of whom 22·8 per cent were children under 15, and 14·7 per cent of pensionable age (men: 65 and over; women: 60 and over). A projection prepared by the Government Actuary for the period up to 1999 predicts a slight decline in the proportion of children, and a rise in the proportion of pensioners to a maximum of 17·9 per cent in 1989. Marriages in 1959 were fractionally higher than in 1958, but the rate per 1,000 unmarried population fell slightly. The number of petitions for dissolution of marriage rose by 88 over the previous year, but at 26,300 was still lower than in any of the years 1945–57. Live births continued rising, and at 748,500 were higher than in any year since 1948. The fertility analysis shows that this is well above the level of replacement. The Registrar General has also issued an illustrated pamphlet *Why a Census* (Pp. 31. London: H.M.S.O., 1961. 1*s.* net) to make the general public familiar with the reasons for the Census taken this year, and to inform them about the questions asked and the techniques used. This is an extremely well-produced guide, which gives an indication of the scope and nature of the census programme and the uses to which the information collected can be put, in simple language.

L'Homme et L'Espace

A new monthly journal, *L'Homme et l'Espace*, made its appearance in April. It is published jointly by Dunod, 92 rue Bonaparte, Paris, VI^e^, and Editions Spes, Lausanne (No. 1; Avril 1961. Pp. 56. (Lausanne: Actualité Scientifique et Technique S.A., 4 Place de la Riponne, 1961.) Abonnement annuel (12 numeros): Suisse: Fr. 45. France: N.F. 54. Autres pays: S. fr. 54. Prix du numéro: Suisse: Fr. 5. France: N.F. 6.50. Autres pays: S. fr. 8). Its object is to describe, in not too technical a manner, the present developments in space research and technology, and to discuss their wider implications for man. There is a place for a contemplative journal of this type among the many factual and technical publications on the subject, and *L'Homme et L'Espace* promises to fill that place admirably. The first issue is produced attractively, with a wealth of illustrations, and its contents are informative and varied. In the first section, on sciences, there are articles by P. Auger on European space research, M. Golay on the necessity for space research and results from it, C. de Jager on the Sun and its variability, and J. Eugster on the radiation barriers to space travel. The topics discussed in the second section, "Literature, Law, History", include ancient ideas on the universe, the predictions of Fontenelle, and space travellers in literature. The last section consists of notes on the night sky in April, comments on various space-research events, a table of satellites and a book list. English and German editions of *L'Homme et l'Espace* are planned.

General and Comparative Endocrinology

The first issue of a new international journal, entitled *General and Comparative Endocrinology*, has been published recently (1, No. 1 (April 1961). Pp. 90. (New York and London: Academic Press, Inc., 1961.) Vol. 1 (6 issues), 1961: 18 dollars). The intention of the editors is to publish original work on cellular mechanisms of hormone action, and on functional, developmental and evolutionary aspects of vertebrate and invertebrate endocrine systems. Occasional brief reviews dealing with particular aspects of endocrinology will also be included. The first number contains nine communications which describe work on insects, amphibians, reptiles and mammals. The list of members of the advisory council and board of editors contains the names of scientists of world-wide eminence, and this should help to ensure that a high standard of publication is maintained.

Bibliography of Interlingual Scientific and Technical Dictionaries

The fourth edition of the *Bibliography of Interlingual Scientific and Technical Dictionaries* includes many works published in the U.S.S.R. As in previous editions, it is arranged according to the Universal Decimal Classification and there are author and subject indexes. Nearly 900 new dictionaries have been introduced since the first edition (1951) and attention is directed to 133 new editions of works previously mentioned. It is proposed in future to bring the Bibliography up to date through the publication of supplements. Corrections, and any information or suggestions for improving the Bibliography, are invited by the Department of Natural Sciences, United Nations Educational, Scientific and Cultural Organization. Copies of the Bibliography are obtainable from H.M. Stationery Office, price 17*s.* 6*d.*

The British Museum (Natural History)

The British Museum (Natural History) has just issued a new edition of *A Short Guide to the Exhibition Galleries* (eighth edition. Pp. vi + 32. London: British Museum (Natural History), 1961. 1*s.* 6*d.*).

The *Guide* follows the modern format which has now entirely replaced the rather text-book-like editions of earlier days. A useful plan of the ground floor is followed by a short historical sketch of the Museum and a description of the exhibits in the Central Hall including the bays together with an outline of the chief features in the Geological, Zoological and Mineralogical Galleries. As the Botanical Gallery is at present under reconstruction, the only botanical exhibits shown are those in the bays of the North Hall. The *Guide* is well illustrated and includes useful details concerning the library, other publications, the Children's Centre and general information about the Museum.

Science in Antarctica

An interesting assessment of the need for future research programmes in Antarctica has recently been produced by the U.S. Committee on Polar Research of the National Academy of Sciences—National Research Council (*Science in Antarctica;* A Report by the Committee on Polar Research. Part 1: *The Life Sciences in Antarctica*. Pp. xi+162. Part 2: *The Physical Sciences in Antarctica*. Pp. xi+131. (Publications Nos. 839 and 878.) (Washington, D.C.: National Academy of Sciences—National Research Council, 1961.) 1.50 dollars each part). The Committee has drawn on leading scientists in the United States to write individual chapters, in each of which the present state of knowledge in a particular discipline is outlined, and possibilities of future developments of research in that field are discussed.

The length of individual chapters, excluding the useful bibliographies, varies from two pages on the "General Ecology and Physiology of Antarctic Fishes" and the "Antarctic Magnetic Programme" to sixteen pages on "Antarctic Glaciology". The report has been published in two parts, and it is of interest to note that Part 1, dealing with "The Life Sciences in Antarctica", covers 162 pages compared with 131 pages on "The Physical Sciences in Antarctica". Although this is due partly to more detailed bibliographies covering the life sciences, it also serves to indicate the increased emphasis which the U.S. Committee on Polar Research would like to place on these disciplines which received little support during the International Geophysical Year. In fact, the introduction points out that the contributions of the United States to Antarctic biology are not great compared with those of other countries, and they hope that the present report will publicize the excellent opportunities in such fields for workers in the United States. The report on physical sciences includes chapters on cartography and geology, two fields of work not included in the programme for the International Geophysical Year. These are included under the section on the "Earth's Crust and Core"; other sections cover the "Heat and Water Budget of Antarctica" and "The Upper Atmosphere". The report has been produced primarily to stimulate interest among scientists within the United States in their Antarctic programme, as well as to emphasize the need for such an effort. It also forms a most useful reference source for scientific administrators connected with Antarctic programmes. The distribution of such reports outlining views of leading scientists on the most promising lines of research during the next five years is in keeping with the best traditions of science and the general atmosphere of international scientific co-operation in Antarctic matters which now prevails.

Nuclear Geochronology

Throughout the world more than a thousand research workers are engaged at present in determining the ages of rocks and minerals by methods based on radioactive decay, and as a consequence of this extensive activity it has of late become increasingly difficult for the average geologist to keep track of the many advances in absolute geochronology. Non-specialists will therefore be indebted to two new works which summarize the latest progress in this field. The New York Academy of Sciences has just published the record of last year's conference on "Geochronology of Rock Systems", edited by Prof. J. L. Kulp of Columbia University, to which more than seventy workers of many nationalities have made contributions (*Annals of the New York Academy of Sciences*, Vol. 91, Article 2. Pp. 159–594. New York: New York Academy of Sciences, 1961). Simultaneously, the Academy of Sciences of the U.S.S.R. has issued a lengthy volume in Russian on *Yadernaya Geokhronologiya* or "Nuclear Geochronology" (630 pp., 1961. Price 3.13 new roubles. Moscow, Academy of Sciences of the U.S.S.R.) which is the work of Dr. I. E. Starik of the Radium Institute in Leningrad. One of the most significant features of these publications is a growing recognition of the extent to which apparent ages are dependent on metamorphic history. A new geochronological time-scale produced by Dr. Starik from Russian evidence is in tolerably good (but far from complete) concurrence with the Holmes-Kulp chronology of the geological systems announced last year, and elaborated lately by Prof. Kulp in a comprehensive review contributed to *Science* (133, pp. 1105–1116, April 16, 1961). Both the American and Russian time-scales agree that the Silurian period, with a duration of only 20 million years, is by far the shortest in Palæozoic time—a conclusion which must surely cause Murchison to turn in his grave.

Conservation of Water

The sixth annual report of the Tweed River Purification Board covers the year ending May 15, 1960, and thus deals with events occurring during the dry summer of 1959 (Pp. 39. Newton St. Boswells: Tweed River Purification Board, 1960). In this connexion the Board is concerned with the increasing demands being made on available water supplies—in particular, the use of spray irrigation by farmers may consume very large quantities, and the Board considers that legislation on this subject should be introduced at an early date. The value of the re-use of water by industry was exemplified at some sand and gravel washing plants in the Board's area—in some cases streams would have been pumped dry and production would have been restricted if the washing water had not been re-used. It is encouraging that the report records that rivers were in a generally cleaner condition, and fish mortality in the main rivers was substantially less than during the dry conditions of 1956–57.

Cambridge Rheology Club

The first discussion meeting of the Cambridge Rheology Club, which was inaugurated on April 24, was held on May 29 at the Technological Research Station, Spillers, Ltd., Cambridge. Dr. J. R. A. Pearson (Department of Chemical Engineering, University of Cambridge), the chairman for the evening, welcomed the two visitors, Dr. M. A.

Payman (Charing Cross Hospital) and Dr. G. W. Scott-Blair (National Institute for Research in Dairying, University of Reading). The discussion on "Some Recent Research Problems encountered in the Study of Blood as a Rheological Fluid" was opened by Drs. D'A. Kok (Department of Medicine) and P. A. G. Munto (Anatomy School). A lively exchange of ideas followed with contributions mainly by the opening speakers and Drs. P. Johnson and A. T. Rowe (Department of Colloid Science), Dr. P. R. Lewis (Anatomy School) and Dr. N. A. de Bruyne (Techne, Ltd.). It was announced that the next meeting would take place at the Technological Research Station, Spillers, Ltd., on September 11, when the Cambridge Instrument Company, Ltd., Grant Instruments (Cambridge), Ltd., and Techne (Cambridge), Ltd., will exhibit and discuss rheological equipment. Further information can be obtained from Mr. H. G. Muller, Technological Research Station, Spillers, Ltd., Station Road, Cambridge.

British Conference on Insecticides and Fungicides

The Association of British Manufacturers of Agricultural Chemicals is organizing a "British Insecticide and Fungicide Conference" at the Grand Hotel, Brighton, during November 6–9. The conference is divided into eleven sessions, which include: (*a*) soil pests and diseases, including "The Eelworm Problem", by Mr. F. Jones, "Insecticide Seed Dressings" by Mr. M. J. Way and "Fungicide Seed Dressings" by Dr. Mary Noble; (*b*) systemic insecticides, including "Systemic Insecticides and Virus Control in Potatoes" by Dr. L. Broadbent and "Control of Sugar Beet Virus Yellows" by Dr. Reitberg; (*c*) forecasting of pest and disease outbreaks (Mr. G. H. Brenchley); (*d*) the control of apple mildew (Dr. R. T. Burchill); (*e*) pests of tree fruits (Dr. G. H. Dicker); (*f*) control of *Botrytis* disease (Mr. J. M. Wey); (*g*) control of fungi and nematodes (Dr. Madel); (*h*) newly developed compounds; (*i*) introduction of insecticides into agricultural practice at home and abroad (Mr. M. Cohen and Mr. G. Ordish). Further information can be obtained from the conference secretary, Mr. W. A. Williams, Association of British Manufacturers of Agricultural Chemicals, Cecil Chambers, 86 Strand, London, W.C.2.

New Universities in Britain

In a written answer given in the House of Commons on May 18, the Chancellor of the Exchequer, Mr. Selwyn Lloyd, said that the University Grants Committee had advised him that, within the scope of the building programme already announced, four new universities, in addition to those which are already being established at Brighton, Norwich and York should be established as the best means of providing places for some of the increased number of students expected. He added that the Committee had advised him that three of the four should be at Canterbury, Colchester and Coventry. The location of the fourth is being considered and the Committee hoped to report on this in the next two or three months. It is the Committee's view that the question of the establishment of any new universities beyond these four should await the report of Lord Robbins's Committee on Higher Education. No new university for Scotland was proposed because it was expected that the expansion of the existing Scottish institutions under the building programme already authorized would provide the additional places needed. Mr. Lloyd said he had accepted this advice, and had authorized the University Grants Committee to enter into discussions accordingly. The detailed proposals would take into account existing provision and plans for other forms of higher education in the areas concerned.

Announcements

Dr. T. D. Day, formerly assistant director of cancer research, Department of Experimental Pathology and Cancer Research, University of Leeds, has been appointed to direct the Tobacco Manufacturers' Standing Committee Research Unit, Harrogate.

The following were elected officers of the Salters' Company for the year 1961–62: *Master*, Sir Alexander Todd; *Upper Warden*, T. G. Hicks; *Second Warden*, Rear-Admiral W. K. Weston.

The 407th meeting of the Biochemical Society will be held in the Department of Physiology and Biochemistry, University of St. Andrews, during June 22–23, starting at 2 p.m., when there will be a colloquium on "The Quantitative Estimation of Amino Acids". Original communications will be presented on the following day.

The National Physical Laboratory, Teddington, is organizing a conference on "The Control of Noise" during June 26–28, in collaboration with the National Engineering Laboratory and the Building Research Station. The programme will include: general problems of the control of noise; hearing and the ear; measuring noise; sources of mechanical noise; propagation of sound in air; effects of noise on performance and productivity, etc. Further information can be obtained from Mr. D. W. Robinson, National Physical Laboratory, Teddington, Middlesex.

The eleventh meeting of Nobel prize winners will be held in Lindau during June 26–30. Further information can be obtained from the Sekretariat der Tagungen für Nobelpreisträger, Lindau (Bodensee), Postfach 11.

Hatfield College of Technology is organizing a summer school on the "Mathematics of Automatic Control" during June 26–30. The object of this school is to enable mathematicians and engineers working on problems of automatic control to study some of the relevant mathematical techniques developed in recent years in Britain, the United States and the U.S.S.R. Further information can be obtained from the Academic Registrar, Hatfield College of Technology, Hatfield, Herts.

The Association for the Study of Animal Behaviour is holding a three-day symposium on "Orientation and Migration" during July 11–13 in the Department of Zoology, University of Cambridge. Further information can be obtained from Dr. J. B. Free, Rothamsted Experimental Station, Harpenden, Herts.

Erratum. In the article entitled "Separation of Two Light Reactions in Noncyclic Photo-phosphorylation of Green Plants", by Dr. M. Losada, Dr. F. R. Whatley and Prof. Daniel I. Arnon, in *Nature* of May 13, p. 606, in Tables 2 and 3, entries 2 and 4, the plus sign should in each case precede the word 'Dye'.

GHANA SCIENCE ASSOCIATION

THE Ghana Science Association held for the first time a conference of all scientists in Ghana at Legon in the University College of Ghana during March 31–April 3. This coincided with the second anniversary of the Association, which was formed from the West African Science Association, after Nigeria had asked to form the Science Association of Nigeria about two years ago.

The conference was opened by the Hon. Kofi Baako, Minister of State for Presidential Matters in Parliament, who is also the Minister responsible to the President for National Research. He deputized for the President, Osagyefo Dr. Kwame Nkrumah. The Minister expressed the Osagyefo's great interest in science and its development in Ghana and appealed to the scientists to channel their efforts through peaceful uses of scientific discoveries. He also promised the help of the Government in the publication of a new scientific journal for the Association. The Minister's speech was followed by the presidential address of the Association, which was given by Mr. R. P. Baffuor, principal of the Kumasi College of Technology and the third and this year's president of the Association.

This conference appeared to have met with approval in Ghana, for although many international scientific conferences have been held in Ghana for some time past much publicity was given to this national conference by both the Press and the radio. The theme of the conference was "Science in the Development of Ghana", and no less than twenty-three papers were read in the three days in various branches of science such as physics, chemistry, botany, zoology, geology and geophysics, engineering, agriculture, medicine and soil science. The actual topics were not necessarily limited to Ghana. Most of the papers were of a general nature, and were presented for the understanding of all scientists irrespective of their speciality, but one afternoon was set aside for specialist papers, when the conference split into biological and physical sciences. Geology and soil science formed the biggest group of papers read.

The most popular paper was on traditional healing methods in Ghana, by Mr. W. S. Mensah-Dapaa, a Ghanaian science graduate who, for about two years, has been living at the shrine of a famous traditional healer at Larteh, a village about thirty-five miles from Accra. In his paper Mr. Mensah-Dapaa described in great detail the ceremony that surrounded the healing at this shrine and gave eye-witness accounts of the spectacular cures that had taken place there. He certainly aroused interest in this field, which has often been relegated to the limbo of non-scientific or quasi-spiritual practices. He appealed to the scientists to shed many of the false ideas about traditional healing, so that the best of this cult, which he claimed to be Africa's version of what prevails in varying forms all over the world, may be successfully studied and integrated into science and medicine. He also called for a department under the proposed medical school for studying the herbs and the methods of traditional healing.

Contributors were selected from all over Ghana, from the University College of Ghana, the College of Technology, research institutions like the West African Cocoa Research Institute, the Government Scientific Civil Service, and private individuals.

One significant and encouraging aspect of the conference was that for the first time an appreciable number of young Ghanaian scientists read more than one-third of the papers.

On the first full-session day, April 1, nine papers were read. The Rev. Dr. J. R. Koster, the first scientist to record sounds from the Russian satellite in 1957, read a paper on "Radio Research in Ghana". He discussed the discovery of some unusual equatorial radio propagation problems in Ghana which affect television and radio broadcasting in Ghana and elsewhere. This was followed by an illuminating talk by Mr. O. W. Snow, adviser on agricultural science to the Government of Ghana, on "Agricultural Research in Relation to Development". With particular reference to the Gezira Cotton Scheme in the Sudan Republic, Mr. Snow showed how the proper utilization of the great potential of the results of agricultural research depended largely on other factors, such as systematic layout, availability of credit and some legalized form of marketing.

After this had been followed by the paper on traditional healing methods referred to above, Mr. A. Foggie, adviser on forestry matters, read his paper on "Conservation of Natural Resources in Ghana". He covered the problems of conservation of water, vegetation, soils and wild-life in Ghana. Another paper of great interest that day was one on "Radio Isotope Unit", by Dr. A. H. Ward, of the Physics Department of the University College, in which were described the various work being carried out in Ghana with radioisotopes and the potentialities of the Radio Isotope Unit installed at the University College. Other papers for the day included the following: "Some Aspects of Genetic Expressions in Agricultural Experimentation in Ghana", by Dr. Agble, deputy chief scientific officer; "Grain Storage Problems in Ghana", by Mr. J. Forsyth, of the Faculty of Agriculture at the University College of Ghana, and finally, "The Role of Geology in the Development of Ghana", by Mr. L. A. K. Quashie, of the Geological Survey Department.

The following day was devoted to the specialist lectures. Under the chairmanship of Prof. W. J. McCallien the Physical Sciences group heard three papers. The first of these, which drew many listeners, was on "Geological and Archæological Evidence for the late Quaternary Climatic Sequence in West Africa", by Dr. O. Davies, a well-known archæologist who continues to make valuable contributions in this field in Ghana. This was followed by a paper by Dr. F. Torto, of the Department of Chemistry, on the structure of gums and mucilages in two Ghana plants, *Fagara xanthoxyloides* and *Afraegle paniculata*. The final paper of the day was on "A Seismic Investigation of the Depth of Bedrock under the Volta River at Tefle", by Mr. F. W. Hales, senior geophysicist of the Geological Survey Department. He showed that the refraction method of analysis corroborated the depth-to-bedrock data obtained by drilling at the site of the proposed bridge across the Volta River at Tefle.

The Biological Sciences group, under the chairmanship of Prof. F. W. Sansome, heard two papers on cocoa—one, "Comparable Growth Rates of Amazon and Amelonado Cocoa and Responses to Fertilizer", and the other, "Problems in the Assessment of Cocoa Varieties". The third paper was entitled "Liver Cirrhosis in Pigs in Ghana", in which the speaker, Mr. D. Zwart, introduced for discussion the problem of liver cirrhosis which attacked the local black pigs, and later also a few of the European ones, when kept under semi-intensive conditions.

The final full session day of the conference, April 3, opened with one of the popular topics, "Tuberculosis in Ghana", by the tuberculosis specialist in Ghana, Dr. A. Koch. Then followed a general paper by Prof. McCallien on "Seas and Oceans", treated with reference to geological problems in recent oceanographic studies.

Quite related to this topic was the next paper on "Outboard-Motor as a Prime Mover in the Development of Fisheries in Ghana", by Mr. E. A. Kwei, of the Government Fisheries Department. Among the other papers for the day were "The Correlation of Field, Laboratory and Analytical Studies of Engineering Structures", by Prof. Royston-Jones, of the Engineering Department, and "Classification of Black and Grey Clays of Ghana using the New U.S. System" presented by three workers led by Mr. H. B. Obeng, of the Scientific Services.

The closing address to round off the conference was given by Mr. H. O. Walker, former chief meteorologist, who made special mention of the many new Ghanaian scientists.

Arrangements are being made to publish the proceedings of the conference in the new scientific journal of the Association. J. YANNEY WILSON

SATELLITES AND GEODESY

ON March 24, 1961, the Royal Astronomical Society held, at its rooms in Burlington House, a geophysical discussion on "Technique of Optical Observations". The chairman for the meeting was Dr. A. H. Cook (National Physical Laboratory), who opened by remarking that the exploration of the major feature of the Earth's gravitational potential by the conventional methods of geodesy was a topic which had often been discussed at meetings of the Society. This meeting, however, would be concerned rather with the elucidation of small-scale features and the use of observations of Earth satellite positions for this purpose.

The discussion was opened by short papers from four speakers, of whom the first was Brigadier G. Bomford. Geodesists had no difficulty, he said, in deriving the size, latitude and longitude and an appropriate geoid for a piece of land, using a variety of well-known astronomical measurements. The problem was to relate the resulting co-ordinate systems for two or more land masses which were separated by a wide sea. If there were no gaps of more than, say, 500 miles to be spanned, the land masses might be connected in latitude and longitude by radar, but this would not connect the two geoids.

However, the problem might be solved by a sufficient number of simultaneous observations of the position of a satellite from each of the land masses to be connected. It was possible that non-simultaneous non-overlapping observations might be used, but this might also assume a knowledge of the geoid. Brigadier Bomford suggested that such observations would need, in order to be useful, to lead to measurements of position with an accuracy of 30 miles in a horizontal and 10 miles in a vertical direction. Connexions of this kind were required, for example, between Europe and America, across the Mediterranean and between many separated land masses in and around the Pacific.

Dr. R. d'E. Atkinson (Nautical Almanack Office) discussed the astrometric techniques which might be employed, of which there were several. One of the most convenient required the satellite to emit bright, short-duration flashes of light, which would then be photographed against the stars using a camera with an equatorial drive. If the stations were at known longitudes and latitudes, then the time of the flash was in general determined, but if longitude errors in the positions were to be taken out, a timing system with an accuracy of 1 msec. was required.

In this way, accuracies in the star positions of 0·05" could be obtained, but this was because the long exposure reduced errors due to 'seeing' (that is, irregular variations in tropospheric refraction). At low altitudes this effect might be very important and unfortunately connexions over long distances would usually involve large zenith distances. Thus, at a zenith distance of 70° in a particular case, he had found that 'seeing' increased the angular diameter of the image from 2" to 4·8", suggesting that the probable error of a single observation of a satellite might be 2", equivalent to perhaps ± 60 miles in position. But with multiple observations there would be an improvement.

Alternatively, the conventional method of observing a satellite by reflected sunlight could be used, the observations being made by means of a camera having a shutter which would make timed breaks in the trail. This would be nearly as accurate. The principal problem in this case was to obtain east–west connexions over long distances, as each of the stations could not then be in the dark.

The third paper was read by Dr. A. P. Willmore (University College, London), who pointed out that a principal instrumental difficulty in making optical observations of satellite positions arose from the fact that, viewed from a point on the Earth's surface, a satellite moves with an angular velocity which is neither constant nor accurately predictable. The problem was then to obtain a sufficient exposure to record its position. The sensitivity of a detecting system might in general be limited in any of three ways: by the necessity for recording at least a few photon events in each image element, by statistical fluctuations in the background due to the night sky or by system noise (such as chemical fog, in the case of a photographic emulsion). When these were examined for any but a rather small optical system, it was found that at the high quantum yields characteristic of a photoelectric detector, the limitation always arose from the night sky background, while at the lower quantum yield of the photographic

plate, chemical fog determined the sensitivity. It could be said that the practical limits for stationary detectors were at about mag. 9 for a photographic and mag. 11 for a photoelectric detector. It appeared that by tracking the camera at the predicted angular rate of the satellite, a gain of about mag. 5 could be obtained.

In fact, the only precise tracking system of high sensitivity in operation was photographic. This was operated by the Smithsonian Astrophysical Observatory, using the specially designed Baker–Nunn cameras. These have an $f/1$ Super-Schmidt optical system of 20 in. focal length. The cameras are tracked at the predicted angular rate and satellites at a brightness of mag. 13 have been recorded.

However, systems using photoelectric detectors are being studied actively—one, for example, using image intensification by Prof. J. D. Magee at the Imperial College of Science and Technology, London, and another, using photomultipliers, at University College, London.

The advertised speaker for the last paper, Mr. W. H. Guier (Johns Hopkins University), was unfortunately unable to appear, and his place was taken, at rather short notice, by Dr. G. V. Groves (University College, London). This was an account of a radio system which offered some promise as an alternative to optical observations, namely, that employed in the *Transit* series of satellites. This requires on the satellite two or more high-frequency transmitters, with a very-high-frequency stability over the observing period of several minutes. The frequency of the transmission received at the ground is measured as a function of time. Naturally, it is not constant, but diminishes during the satellite passage, on account of the Doppler shift. The principle of the method can be very roughly described by saying that the total change of frequency during the passage is proportional to the velocity of the satellite, while the maximum rate of change depends both on the velocity and the slant range at closest approach, which can then be determined. It is necessary to make a correction for ionospheric effects, which amount to about 0·2 per cent at 100 Mc./s. They are almost inversely proportional to frequency, and can be calculated if two or more transmitters are used.

The method was first applied with encouraging success to the determination of orbital elements of the first satellites by W. H. Guier *et al.* Later, the transit system was tested in a trajectory determination of an *Atlas* rocket with an apogee height of 700 km. where comparison with a trajectory determined by radar showed differences of a few km., to which the errors of the radar would have contributed.

It has now also been used on the *Transit* 1 satellite. Observations were made at six ground stations in the northern hemisphere, and the orbital elements determined, taking the observations for one day at a time, by reproducing to the best fit the observed frequency-time curves. It was found possible to obtain the coefficient of the third harmonic in the gravitational potential with an accuracy of about 5 per cent, and since this produces oscillations of about 5 km. amplitude, it was concluded that the accuracy of measurement was 0·5 km. It seems possible that an improvement in accuracy of an order of magnitude should be obtainable, resulting in position measurement with an accuracy of about 50 miles.

It is intended to use the *Transit* satellites for navigation, by storing up-to-date orbital elements on a tape recorder in the satellite. These would be read out on command by the ship and combined with Doppler shift observations to obtain the ship's position. During the ensuing discussion, the importance of this for gravity surveys at sea was mentioned by B. C. Browne (Cambridge), as in such observations a principal difficulty is the determination, with adequate precision, of the ship's position.

A. P. Willmore

GEOCHEMICAL EFFECTS OF WEATHERING

A JOINT meeting of the Clay Minerals Group of the Mineralogical Society and the British Society of Soil Science, held in the School of Agriculture, University of Cambridge, during April 6–7, was attended by approximately 100 delegates from home and overseas. At the two paper-reading sessions, the chair was occupied on the afternoon of April 6 by Prof. J. White (Sheffield) and on the morning of April 7 by Dr. H. Greene (Rothamsted Experimental Station). The topic, weathering, was discussed from many points of view (for example, mineralogical, geological, pedological and geochemical) and the conference concluded with the alternative of an excursion led by Mr. C. A. H. Hodge (Rothamsted Experimental Station) to the Brecklands area or informal visits to laboratories of the University.

Prof. C. W. Correns (University of Göttingen), in the introductory paper, outlined the experimental work done on the decomposition of mineral powders by aqueous solutions. Plastic was used in the apparatus and factors such as particle size, rate of flow, temperature, and *p*H of solution were shown to be important in determining the nature of experimental reactions with potash-felspar, albite, leucite, muscovite, tremolite, olivine and sideromelane. The results of recent experiments on the decomposition of kaolinite and montmorillonite at *p*H 7 could be of significance in the origin of bauxite. The main findings of the whole study were summarized by Dr. G. Nagelschmidt (Sheffield) to the effect that in open systems and at low temperatures, minerals tend to decompose as ions with formation of amorphous residual crusts, whereas in closed systems and at high temperatures secondary minerals are formed. He also directed attention to the formation in Nature of pseudomorphs of kaolin after felspar, and Prof. Correns commented that in an open system and over a long period this might be possible.

An experimental study of the geochemical alteration of acidic and basic igneous rocks under varying hydrodynamic and physiochemical conditions was described by Dr. G. Pedro (Versailles). Special attention was paid to the secondary formation of iron and aluminium oxides and hydroxides. The value of the ratio of $SiO_2 : (RO + R_2O)$ was found to be greater in the leachates than in the unaltered rocks. Prof. White expressed surprise at this, but Dr. Pedro thought that it might possibly be explained by the high *p*H in the system. Asked whether trace elements had been determined, Dr. Pedro replied that these results would be available very shortly. After several comments on the altera-

tion products, a delegate described an apparatus made of tin which had been found more successful than glass.

In contrast to these experimental studies, two papers were given on natural weathering. In the first, Dr. W. W. Smith (Macaulay Institute) described the weathering of basalts and dolerites from the south-east of Scotland and the mineralogy of the resultant soils. The relative stabilities of the primary minerals in the fine sands were given, and the secondary weathering products in the rocks and soils were discussed. Contamination by glaciation had to be taken into account. With reference to the quantitative analyses of fine sands by X-ray diffraction, Dr. R. M. S. Perrin (University of Cambridge) stressed that, due to limiting factors in the method, the figures should not be taken as exact and care in interpretation is necessary. In the second paper, Mr. D. F. Ball (Bangor) described a deep profile on the Isle of Rhum in which 50 ft. of weathered gabbro is preserved under glacial drift. A thick reddened zone with high content of free iron oxide was likened to the *B* horizon of a podzol and the whole formation was considered to be a relic of interglacial weathering in a tor-like topography. Mr. L. Berry (University of Khartoum) commented that such red zones, because of their frequent discontinuity, can be difficult to interpret, but the tor-like topography is similar to that produced in humid warm climates. Reference was made by Mr. R. H. S. Robertson (Pitlochry) to red Tertiary interbasaltic weathering. Dr. R. Glentworth (Macaulay Institute) contrasted certain deeply weathered (possibly pre-glacial) granite and basic igneous exposures in Aberdeenshire with the buried parts of a granite stone circle which appear to have weathered 3 in. in approximately 3,000 years.

The usefulness of drainage-water analysis in studying the processes of weathering and soil-formation was illustrated by Dr. Perrin. Care in sampling, a knowledge of hydrology, percolation rate, and possibly composition of rain-water are all necessary and applicable in determining absolute loss of material or relative loss of elements. Instances where such analyses could provide useful information include the movement of iron in ground water gleys, problems in salt-marsh reclamation, the rate of weathering of chalk, and the genesis of soils. In addition, Dr. Perrin related the results of chemical analyses to weathering trends in soils formed on Ordovician shales and many of the interesting points which arose in interpreting these results were discussed. Other comments included one by Dr. P. H. T. Beckett (Oxford) on the relative merits of sampling drainage water or water direct from the profile. Awareness of the statistical significance of all results was stressed.

Dr. G. Rosenthal (Würzburg) considered both theoretical and practical aspects of the weathering of porous materials by freezing, and focused attention on the 'freezing-point depression' of water, which is due mainly to high pressure affected by capillary radius, pore surface area and surface tension, etc. The resistance to freezing of sandstones, roofing tiles, and bricks was noted, and it was found experimentally that the freezing temperature of brick was even lower than expected, due possibly to the inclusion of meta-kaolin with free valence-bonds which could hinder re-orientation of water into ice. Further work on surface effects was urged before tackling rocks. Asked about the effect of ion concentration, Dr. Rosenthal stated that in brick this lowered the freezing point only very slightly, but in soils and clays it would be more important. Calculations for soils would also be complicated by the wide range in pore size, and when dealing with rocks, climatic effects would have to be taken into account.

The origin of English fuller's earths was proposed by Mr. Robertson to be marine rather than volcanic and to be due to a transgression of the sea during the Upper Aptian. The heavy mineral suite above and below the clay in the Sandgate bed was shown to be derived from the old land surface of the London Platform. Uniformity in composition of various widespread montmorillonite deposits was considered as evidence of similar conditions of formation. In reply to Dr. Nagelschmidt, Mr. Robertson suggested that the seas would have been mainly calcium ion-saturated and that any sodium ions could have been absorbed by the adjacent more porous formations. A possible tie-up in conditions with those in the Piedmont areas of the south-east of the United States was proposed by Dr. A. Muir (Rothamsted Experimental Station) and Dr. Perrin directed attention to the general absence of mica in the fuller's earth deposits.

Finally, two papers were given by Mr. J. E. G. W. Greenwood (Directorate of Overseas Geological Surveys, Tolworth) and by Mr. Berry and Mr. B. P. Ruxton (University of Khartoum) on the weathering of rocks in hot climates. The first showed how the effects of chemical weathering and thermal disintegration on rocks in arid areas can be of significance in the interpretation of aerial photographs. For a variety of igneous and metamorphic rocks, theoretical orders of response to both processes were detailed but disagreed with the observed order since, for example, thermal disintegration is apparently more effective on granite while chemical weathering is more effective on gabbro and diorite. Rock properties such as grain size, jointing, porosity, and texture were shown to have an important influence on weathering processes. In discussion, Mr. Berry advocated experimental work on the effects of thermal disintegration. In the second paper, examples of tropical weathering of granite in humid, monsoonal, semi-arid, and arid climates were chosen to illustrate different weathering features. Generally, factors such as topography, rainfall, and ground water movement were shown to influence profile development. Illustrations included photographs of 'abandoned' hills and foothill zones of laterization and intense weathering.

During the excursion to Breckland, a series of three soils developed from Gipping Till was demonstrated. The first, a very shallow rendzina, was seen at Lakenheath Warren. The other two, situated within Forestry Commission woodland, were a brown calcareous soil and a brown earth with textural *B* horizon at 95 cm. Although time was too short for a visit to a fourth profile, it was obvious that the afternoon trip had provided adequate food for thought.

The symposium, as a whole, was commendable for the wide scope given to the discussion of weathering. The importance of laboratory experiments as an aid to elucidating problems in the field was emphasized, and among recommendations during discussion were included care in choice of apparatus, methods of sampling, and assessment of significance of results. Undoubtedly, the possibilities of future research in the field of weathering are enormous.

WILMA W. SMITH

THE ARTHUR D. LITTLE RESEARCH INSTITUTE

THE annual report for 1960 of the Arthur D. Little Research Institute* records an average expansion since 1957 of about 20 per cent per annum. Sixty-five per cent of its income comes from industry and 35 per cent from Government and related agencies, about half its sponsors being British and European and the rest American. Practically all the Institute's work is classified as oriented fundamental research, and has so far been predominantly concerned with the chemistry of plant materials. The Biochemistry Section was established in 1960 to undertake the study of biochemical problems where newer techniques, such as starch-gel and high-voltage electrophoresis and paper and column chromatography with automatic densitometry, are already having their impact. Work has been initiated on the separation of the wheat gluten gel complex into its components.

The Organic Chemistry Section continued work on the polymerization of glucose and its derivatives, and already polyamides with viscosities comparable with those of nylon have been obtained using the new technique of interfacial polycondensation. In the work on the chemical modification of wood, a low-temperature catalytic acetylation process gave wood of permanent shrinkage and only slightly improved dimensional stability. Promising results have been obtained by impregnating wood with monomers and polymerizing *in situ*, and attempts have been made to reduce flammability of wood by introducing non-leachable compounds containing phosphorus. Work was initiated on the release of corrosive volatile vapours from wood at high humidity and high ambient temperatures, that is, greater than 40° C., and also to explore the properties of ethylene sulphide.

In physical chemistry, the Polymer Section continued to study the bulk properties of polyolefins, particularly the kinetics of crystallization of polyethylene, with the view of obtaining a better understanding of the effect of crystal structure on the physical properties, and has shown that the initial crystallization behaviour depends markedly on molecular weight. Work was also commenced on the kinetics of the reaction between molten aluminium and water.

The Metallurgy Section completed a three-year study of corrosion involving the screening of 470 organic compounds, to ascertain any correlation between chemical structure and inhibitory power, and although no clear-cut correlation emerged, some compounds were found to favour the inhibition of corrosion of mild steel and cast iron in acid solution while others opposed inhibition. A study of the hydrogen embrittlement of certain steels is planned. A list of publications of the Institute is appended with abstracts of those published in 1960.

* Arthur D. Little Research Institute. Annual Report for 1960. Pp. 44. (Inveresk, Midlothian: Arthur D. Little Research Institute, 1961.)

THE WOOL INDUSTRIES RESEARCH ASSOCIATION

IN addressing the forty-second annual general meeting of the Wool Industries Research Association on April 19, the chairman of the Association, Mr. B. A. Smith, after referring to the opening of the new Worsted Processing Block at Torridon on March 22 (see *Nature*, **190**, 313; 1961) by the Right Hon. R. G. Menzies, stressed the need for more research and technical education in the industry. The Association was just ending a quinquennial period in which the grant from the Department of Scientific and Industrial Research had been based on £170,000 of industrial income; under the new £70,000 arrangements this grant would be £59,000 on £170,000 of industrial income, but with a further £75 for every £100 supplied by industry up to a total of £25,000, and Mr. Smith asked for support for any proposal in the near future for an increase in levy.

The report of the director of research, Dr. A. B. D. Cassie, for 1960* refers to progress in constructing an apparatus for the automatic quantitative analysis of mixtures of amino-acids by separating them on a cationic exchange-resin column, converting to copper complexes, and determining the copper content polarographically. Excellent results have been obtained in the automatic assay of basic amino-acids, but citrate buffers cannot be used for chromatography because of the formation of copper-citrate complexes, and new buffer systems are being developed for amino-acid separation. Several protein components of oxidized wool have been isolated by percolating columns of the material with 5 *M* urea solution, gradually changing in *p*H from 3·0 to 5·8, and determinations by Sanger's method of the N-terminal groups of the components isolated from wool following treatment with acid gave average chain-weights of 96,500 and 20,500 for component I and component III, respectively.

Search for a method of determining the moisture content of raw wool continued, and a general survey being made of the diffusion constants of a wide range of organic molecules, from toluene and benzyl alcohol to a non-ionic detergent of mol. wt. 558, indicates that the mobility of a molecule in keratin depends more on its hydrophobic–hydrophilic balance than its size. Work completed on the breaking-time and dynamic elastic modulus of nylon confirms that changes in moisture content affect both the elastic properties and the strength of the structural elements as well as the internal viscosity.

Recent work has shown that at least one of the causes of yellowing of woollen yarn on storage is the presence in the olein of small amounts of polyunsaturated acids: linolenic acid causes permanent yellowing, but the effect of linoleic acid is less

* Wool Industries Research Association. Report of the Director of Research for 1960. (Publication No. 215.) Pp. 39. (Torridon, Headingley, Leeds: Wool Industries Research Association, 1961.)

important, while pure oleic acid has little deleterious action. Laboratory and works trials have shown that the moth-proofing agent 'Dielmoth' can be applied to worsted yarn during normal bleaching processes, but the treated yarn had only poor washing fastness. Fabric construction has been shown to play an important part in the production of fabrics with durable pleats or creases.

THE BENGUELA CURRENT

IN 1953 two interesting articles appeared in *Nature*. The first was by Currie[1] and described the process of upwelling in the Benguela current. He showed that in addition to the upwelling inshore, a convection cell develops at the edge of the continental shelf which separates the cold upwelled waters from the warm oceanic waters further out to sea. This line of demarcation is used in a recent report * to define clearly what is meant by the Benguela current: "We have restricted the use of the name Benguela current to the coastal circulation in which upwelling movements occur and have referred to the oceanic circulation as the 'south-east trade wind drift'."

The second article was by Hart[2] and dealt with the preliminary results of the phytoplankton surveys. He stressed the distinction between oceanic species of the south-east trade-wind drift and the coastal forms in the rich upwelled waters. In the latter he introduced the new conception of ageing of upwelled water, by which was meant the succession of species as the characteristics of the water mass change.

In the present report the two authors have enlarged on these preliminary findings. New data on winds, surface drift, bottom topography, water temperatures, salinities, dissolved oxygen, phosphate and the species composition, density and distribution of the microplankton have been analysed and co-ordinated to form an impressive picture of the oceanography of the seas off south-west Africa.

After summarizing the results of earlier investigations, the two cruises of R.R.S. *William Scoresby* off south-west Africa are described. The first was in the southern autumn (March 3–14, 1950) and the second was in spring (September 21–October 12). They go on to show that the winds are the driving force behind the currents. Off the shelf, the south-east trades cause a drift which Defant[3] has shown to be north-north-west, parallel to the coast. Nearer the coast and on the shelf itself, there are coastal winds which are mainly south-south-west and these induce a current away from the shore and upwelling results. Many charts and sections show that this upwelled water differs from the oceanic water in temperature, salinity, dissolved oxygen and phosphate concentration. In spite of complexities due to swirls and interlocking tongues of water, the dividing line lies approximately over the edge of the continental shelf. Moreover, the vertical sections show clearly that on this line the isotherms and isohalines above the 300-m. level have an upward kink and that water from the 200–300-m. level reaches the surface inshore. The kink in the isotherms is the result of the convection cell which separates the two water masses and is well illustrated in a section which shows the distribution of the anomaly of specific volume off the mouth of the Orange River during the spring survey when active upwelling was in progress. It is suggested that conditions in the Benguela current are similar to those in upwelled waters off California where Sverdrup[4] has described a similar convection cell.

The evidence that the upwelled water comes from the 200–300-m. level denies once and for all the vague idea that the Antarctic intermediate current is concerned, for the latter lies at the 600–800-m. level. The water at the 200–300-m. level is part of the South Atlantic central water and its origin is controversial. Possibly it is the result of sinking at the sub-tropical convergence. Off south-west Africa there is a general movement to north-north-west at this level, but there are also indications, based on admittedly slender evidence, of a southerly movement along the edge of the shelf. "It is postulated that this is a compensatory movement replacing the water which has been drawn up to the surface inshore and we have therefore called it the compensation current." Vertical sections of salinity, temperature and phosphate show no discrete body of water at this level, nor is the existence of this southerly current essential to the main argument, and I doubt its existence. Indeed, the distribution of the oxygen minimum layer in the South Atlantic shown in Fig. 47 is more readily understandable as a north-westerly drift of the products of decay from the highly productive areas off south-west Africa.

The second part of the report deals with the microplankton as sampled by *N.50.Y.* nets. The bulk of the catch was diatoms and peridinians. After dealing with the vexed question of terminology in which the term 'panthallassic' is revived to cover species which at different times are both neritic and oceanic, the authors give a full list of the species identified and select from this the dominants for further discussion. Their distribution is charted and their density discussed in relation to distance from the shore. In broad outline they found a dense growth of chætocerids and some other neritic species in the area of upwelling, a scant growth of *Planktoniella sol* and other oceanic forms off the shelf and a poor flora of panthallassic species in between. It is stressed that the many differences between the spring and autumn surveys may not be purely seasonal effects but the result of ageing of upwelled waters: "The more extensive coastal production in autumn (survey 1) with numerous resting spores of the dominant chætocerids is thought to represent a late stage in the succession of waters earlier enriched by upwelling . . . the succession may be repeated several times annually." This section ends with valuable notes on the ecology and distribution of the more important species and most ecologists would agree with the final warning that it is not the presence or absence of a particular species which defines a particular water mass but the differing proportions of the species within them. Statistical methods for the discrimination of floristic groups are now being developed.

Finally, the authors come to the controversial question of the mass mortality of fish in the Walvis Bay area and the cause of the anaerobic deposits which extend along the shelf for some 400 miles.

* Discovery Reports, Vol. XXXI. *The Benguela Current*. By T. John Hart and Ronald I. Currie. Pp. 123–298. (Cambridge: At the University Press, 1960.) 75s. net.

Brongersma-Sanders[3] has suggested that the mass mortality is due to poisonous blooms of dinoflagellates such as *Gymnodinium*, but this is discounted. It is argued that the decay of dense plankton on the shelf leads to a depletion of oxygen at the lower levels. Under normal meteorological conditions the currents bring in new supplies of oxygenated water, but during periods of calm, stagnation occurs and anaerobic conditions develop at the bottom which favour the growth of sulphate-reducing bacteria and the evolution of poisonous sulphuretted hydrogen. Oxygen depletion actually extends to the surface inshore and there are press reports from Swakopmund of the sea bubbling with hydrogen sulphide and mud islands rising to the surface. This, the authors infer, is the cause of the mass mortalities of fish, and certainly their meteorological evidence and vertical sections of dissolved oxygen tie in neatly with the theory.

The authors have shown that the Benguela is one of the richest currents in the oceans of the world. This impressive report provides a firm basis for its further study. J. H. Day

[1] Currie, R. I., *Nature*, **171**, 497 (1953).
[2] Hart, T. J., *Nature*, **171**, 631 (1953).
[3] Defant, A., *Landerkdl. Forsch. Festschr. N. Krchs.*, 52 (1936).
[4] Sverdrup, H. U., *J. Mar. Res.*, **1**, 155 (1938).
[5] Brongersma-Sanders, M., *Arch. Neerdl. Zool.*, **7**, 291 (1945).

NATIONAL FORESTS OF AGRICULTURAL CROPS FOR THE WET HUMID TROPICS

By ANTONY SANTIAGO
c o Department of Agriculture, Malaya

THE natural vegetation of the wet humid tropics consists of extensive forests of large and valuable timber trees. These large trees are of paramount importance in protecting the soil of the hillsides from erosion and its consequences, and they make the best use of the leached and acidic soils commonly found in the wet humid tropics. This forest of large trees has been, and is being, selectively destroyed to make way for 'planned forests' of agricultural crops such as rubber and oil palm, which are also able to make good use of such soils. There has been, however, a certain amount of misuse of such land in certain areas where food crops, mostly annuals, such as vegetables and short-lived perennials, such as papayas, have been cultivated. Such crops do not provide adequate cover to the soil, which is exposed to the elements and gives rise to serious soil erosion and unproductivity of the land. Such land has often been abandoned to fallow, and a system of shifting cultivation has been practised.

An ecological and economic study of the wet humid forests of certain agriculturally important large tree crops will show that there is a definite place for developing national forests of certain agricultural crops, which can grow under semi-wild conditions and which need occasional attention for satisfactory growth and crop-production. In Malaya, such agricultural crops are *Durio*, *Nephelium*, *Bertholletia*, *Garcinia*, *Lansium*, *Baccaurea* and *Metroxylon* species.

Most of the tree crops mentioned have the following characteristics :

(*a*) A number of them to this day is grown successfully under semi-wild conditions, and it is doubtful whether it is more economical to grow them under refined cultural techniques.

(*b*) The trees grow to a large size and would function effectively as binders of the soil and efficient utilizers of leached and acidic soils, as the natural forest-trees do.

(*c*) It is questionable whether such crops should be grown by smallholders who have only small pieces of land.

(*d*) The trees take 7–15 yr. to mature and are therefore not ideal for smallholders who lack capital for growing perennial crops. On the other hand, perennial crops are ideal from the point of view of the little work required to maintain crop production.

(*e*) The trees are seasonal in bearing, although there is one season of heavy bearing and another negligibly light one annually.

(*f*) There is negligible damage done to the trees in the process of harvesting the produce and is unlike rubber-tapping, which is done daily, and where inexperienced labourers can damage the trees permanently.

Therefore seasonality of fruiting, semi-wild conditions of growth to large trees and negligible damage done to such trees during the harvest provide conditions which not only find employment for labour that is occasionally unemployed at certain times of the year in the country, and prevent erosion of soil which is a national asset, but also permit the public to harvest the produce on annual lease, which can be called by tender.

Some of these trees have good durable timber, and should the trees go out of production (and this will only occur after several decades) the timber produced would give some remuneration.

At this point a question may be raised about finding planting material and the need for ensuring that planted trees bear high quality and quantity of produce. This is possible by adopting the following theoretically sound but yet unproved technique :

Seeds from trees selected for quality and quantity of produce will, in most cases, be satisfactory as planting material since this technique is practised to this very day in most of these tree crops. However, the individuals will vary in quality and quantity of the produce. In order to minimize the variability it is suggested that in planting the seedlings, twice or thrice the usual number of plants, at closer spacing, can be planted within a unit area, so that it would be possible to destroy progressively half the number of the poorer trees within a unit area, from the time the trees start bearing, to permit good growth of the remaining better trees.

By these methods, therefore, it is theoretically possible to create national forests of agricultural crops in the wet humid tropics where large acreages are still under forests. However, capital will be the problem and this may be found should the national policy-makers be convinced that the idea of national forests of agricultural crops in the wet humid tropics is sound not only theoretically but also practically.

GAS-LIQUID CHROMATOGRAPHY OF STEROL METHYL ETHERS

By R. B. CLAYTON

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SEVERAL reports have appeared recently of the separation of sterols and steroids by gas-liquid chromatography on a variety of liquid phases[1–4]. Up to the present time, however, no correlation has been reported between the structures of steroids and their behaviour on the gas-liquid chromatogram which might allow an accurate prediction of retention times on the basis of molecular structure[5]. Such a correlation is being attempted with the methyl ethers of neutral sterols chromatographed on polyethylene glycol succinate as the liquid phase and some preliminary findings are discussed here.

Preparation of sterol methyl ethers on a 'micro' scale (5–500γ) was carried out in 78–90 per cent yield by reaction of the sterols or their esters with methyl iodide in ether solution in the presence of potassium *t*-butoxide.

Gas-liquid chromatography was carried out using 6 ft. × 4 mm. metal columns packed with 5 per cent polyethylene glycol succinate on 'Chromosorb *W*'. The column was conditioned at 202° for 48 hr. with a slow argon flow. Operating conditions were: column 195°, vaporizer 350°, ionization detector 212°. Gas flow: 220 c.c. per min. (argon). Retention times, tabulated below, are relative to that of cholestane (retention time, 8·5 min.).

The values recorded in Table 1 show that good separations can be achieved with a number of sterols of biochemical interest and with retention times usually between 30 and 60 min. The technique has been applied to the analysis of sterols and their esters isolated from tissues by established methods.

Table 1. Relative Retention Times of Sterols as Methyl Ether

	Cholestane	1·00	
I	Cholestanol	3·60	
II	epi-Cholestanol	2·61	
III	Coprostanol	2·36	
IV	epi-Coprostanol	3·08	
V	Cholesterol	3·90	
VI	Δ^8-Cholestenol	4·15	
VII	Δ^7-Cholestenol	4·70	
VIII	Δ^6-Cholestenol	3·88	
IX	$\Delta^{8,14}$-Cholestenol	3·73	
X	$\Delta^{8,14}$-Cholestadienol	4·56	
XI	$\Delta^{8,22}$-Cholestadienol	3·83	
XII	$\Delta^{8,7}$-Cholestadienol	5·50	
XIII	$\Delta^{8,26}$-Cholestadienol	5·40	
XIV	Ergostanol	4·81	
XV	Δ^8-Ergostenol	5·12	
XVI	$\Delta^{8,22}$-Ergostadienol	4·43	
XVII	Δ^7-Ergostenol	6·05	
XVIII	$\Delta^{7,22}$-Ergostadienol	5·55	
XIX	$\Delta^{5,7}$-Ergostadienol	7·30	
XX	$\Delta^{5,7,22}$-Ergostatrienol	6·52	
XXI	$\Delta^{5,24(28)}$-Ergostadienol	6·08	
XXII	Stigmastanol	6·03	
XXIII	Δ^8-Stigmastenol	6·60	
XXIV	$\Delta^{8,22}$-Stigmastadienol	5·80	
XXV	$\Delta^{8,24(28)}$-Stigmastadienol	7·86	
XXVI	Δ^{22}-Stigmastenol	5·40	
XXVII	Lanosterol	5·32	
XXVIII	24,25-Dihydrolanosterol	4·00	
XXIX	Agnosterol	5·60	

The values shown in Table 1 are most readily interpreted in terms of the operation of three distinct factors: (1) the molecular weight; (2) the polarity; and (3) a 'conformational restriction' factor. These are considered in turn.

(1) *Molecular weight.* The stanols I, XIV, XXII form a series in which the increase in relative retention time is proportionate to the increase in molecular weight. They deviate from the log relationship of true homologous series[6].

(2) *Polarity.* The simplest polarity effects (analogous to those found in adsorption chromatography) are seen in comparing the stanols I and III with their epimers II and IV respectively. Clearly, the more hindered, axial orientation of the three methoxyl group renders the compound more mobile than its epimer in which this group is equatorial. In certain circumstances the weight and polarity factors can largely offset each other. The 4 : 4-dimethyl grouping of XXVII, XXVIII and XXIX (C_{30}) is well known to hinder the 3β oxygen function. Hence these compounds have greater mobilities than XXII (C_{29}).

Compounds having olefinic bonds in the nucleus show greater retention times than their parent stanols. The Δ^7-bond exerts the greatest effect (cf. I and VII, XIV and XVII) of any isolated double bond so far studied. The homoannular, 5,7-diene increases the retention time still further (cf. I and XII, XIV and XIX).

Table 2. Retention Ratios for Unsaturated Structures of Different Molecular Weight

Retention ratio*	Cholestanol	Ergostanol	Stigmastanol	Lanostanol
Δ^7/stanol	1·3	1·26	+	+
$\Delta^{5,7}$/stanol	1·52	1·52	+	+
$\Delta^{5,7}/\Delta^7$	1·17	1·2	+	+
Δ^{22}/stanol	1·08	1·07	1·09	+
$\Delta^{5,22}/\Delta^{22}$	0·98	0·87	0·88	+
$\Delta^{5,7,22}/\Delta^{5,7}$	+	0·89	+	+
Δ^{24}/stanol	+	+	0·90	+
$\Delta^{5,24}/\Delta^5$	+	+	+	1·33
$\Delta^{5,24}/\Delta^5$	1·38	+	+	+
$\Delta^{5,24,28}/\Delta^5$	+	1·18	1·19	+

* Retention ratio = $\frac{\text{relative retention time of compound with } \Delta^x}{\text{relative retention time of analogue lacking } \Delta^x}$

\+ Compounds necessary for comparison not available.

Table 2 lists the ratios ('retention ratios') of the relative retention times of various compounds having certain features of unsaturation to those of their analogues which lack these features. These results show that the introduction of an isolated double bond, Δ^x, into a stanol, *s*, will change its relative retention time, r_s, to a new value $r_{(s+x)}$, according to the relationship:

$$r_{(s+x)} = r_s \times k_x$$

where k_x is a constant ('retention constant') for the double bond in position *x*, which is virtually independent of molecular weight. Further, for two non-interacting double bonds at positions *x* and *y* (for example, Δ^7 and Δ^{22} in the ergostane series) the relative retention time of the new $\Delta^{x,y}$-dienol is given by:

$$r_{(s+x+y)} = r_s \times k_x \times k_y$$

It is apparent that the 5,7-diene must be treated as a unit system in these calculations and the contribution of the Δ^{22}-bond shows an anomaly which is discussed below.

(3) *'Conformational restriction'.* Double bonds originating at C_{24} in the side-chain raise the retention time considerably, but the Δ^{22}-bond fails to increase the retention time. A scarcely measurable negative effect is seen in the cholestane series (V and XI), but in the ergostane and sitostane series the presence of a double bond at C_{22} markedly reduces the retention time. This apparent anomaly becomes intelligible from an examination of molecular models. In compounds without substitutents at C_{24}, the Δ^{22}-bond only slightly restricts the movement of the side-chain, whereas in C_{24}-substituted compounds this restriction is far more pronounced. Such a restriction could lead to some curtailment of solute-solvent interaction and prevent the dissipation of thermal energy in certain modes of intramolecular vibrations which

are available when the side-chain is saturated and hence less restricted. These effects would tend to increase the mobility of these compounds and apparently are great enough to overcome the opposing polarity effect of the Δ^{22}-bond. In Δ^{22}-cholesterol, it must be assumed that the restriction imposed on the side-chain approximately cancels out the increase in polarity which the additional double bond might otherwise confer on cholesterol.

Probably a similar conformational restriction is responsible for the difference between the retention times of cholestanol (I) and epi-coprostanol (IV).

It appears that some advance is being made in this work towards a rationalization of the behaviour of polycyclic compounds on the gas-liquid chromatogram. The concept of 'retention constants' for variously situated functional groups, such as those derived for the double bonds in this work, is an attractive one and may be of considerable practical and theoretical value. However, such constants obviously can only be used with scrupulous attention to the details of the intramolecular environment of the functional groups in question. Moreover, the influence, if any, of the nature of the liquid phase on the values of these constants remains to be determined.

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THE 'LAG-PHASE' IN SALT UPTAKE OF STORAGE TISSUE

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WHEN various dormant storage tissues are washed in aerated water, a characteristic delay in the generation of an absorption capacity occurs for which a wide variety of explanations has been offered. Rees and Skelding[1] suggested that a specific water-soluble inhibitor was present in the tissue which would prevent salt absorption until it had been leached from the tissue. In a later publication, Skelding[2] further supported this view and suggested that the inhibitory substance was formed by dark fixation of accumulated respiratory carbon dioxide. An alternative view, that salt uptake was stimulated as a result of continuous removal of electrolytes from the washed tissue, has been quite persistent[2–5], but was recently disproved by MacDonald *et al.*[6].

Unfortunately, the matter at issue is confounded by the consistent use of tap water, which may vary widely in its mineral contents, and in which the calcium ions present have the property of reducing leakage[7,8]. Dale and Sutcliffe[9], finding that certain organic acids, and also beetroot extracts containing the same organic acids, would stimulate potassium uptake of disks of beetroot tissue washed for a relatively short period (48 hr.), claimed that the lag-phase in potassium uptake was an artefact, and merely a reflexion of a time lag in the development of a chloride accumulatory system. Their results, however, showed that disks which had been washed for 2 hr. could not be stimulated. Probably the most predominant contention at present is that the lag-phase is a period during which a gradual revival of metabolic activity provides the energy required for the formation or activation of carrier molecules participating in the accumulation process[10,11], or for the protein synthesis which is thought by Steward *et al.*[12,13] to be the first requirement for salt uptake.

During the course of testing various compounds for their effect on the lag-phase of beetroot tissue, it was found that 2-amino-2(hydroxymethyl)-propane-1 : 3-diol (*tris*-(hydroxymethyl)aminomethane, or *tris*) had the remarkable property of inducing a rapid rate of uptake of potassium ions immediately after cutting the disks of tissue.

Disks of beetroot (var. Crimson Globe) prepared in the usual manner (1·5 mm. diameter, 1 mm. thick, average weight approximately 180 mgm.), were rapidly washed in three rinses of distilled water to remove materials released from the cut cells before commencing the experimental treatment. Batches of 25 disks (4·5 gm.) were added to each of the 150 ml. of aerated solutions to be tested, kept in 200-ml. boiling tubes and placed in a thermostat. Each treatment was done at least in triplicate. *Tris* solutions were adjusted to the required *p*H with hydrochloric acid. At required intervals, 5-ml. samples of the solutions were drawn off, and replaced by an equal volume of the original solutions, which caused a negligible change in salt concentration. Potassium and sodium contents were determined with an *EEL* flame photometer. The technique is based on the principle that changes in the absorptive capacity of the tissue are detected much more easily at very low than at high salt concentrations.

Fig. 1,*A* and *B* include typical curves for the potassium ion content of the external solution when disks of beetroot were incubated in distilled water. An initial rapid rise of potassium ions in the solution must be expected to originate from the apparent free space and Donnan free space of the tissue. However, an equilibrium should have been reached within the first hour[14], and the continued leaching of potassium ions up to 16 hr. must come from other sources, most likely the cytoplasm and/or the vacuole. The subsequent slow loss of potassium ions from the external solution occurred in the majority of cases; however, with quite a few roots, especially the older ones, leakage surpassed absorption at this stage, resulting in a net loss of potassium ions from the tissue. A marked change always set in at approximately 30–40 hr. from the start of the experiment, resulting in a period of rapid absorption, quite often causing the concentration of potassium ions of the external

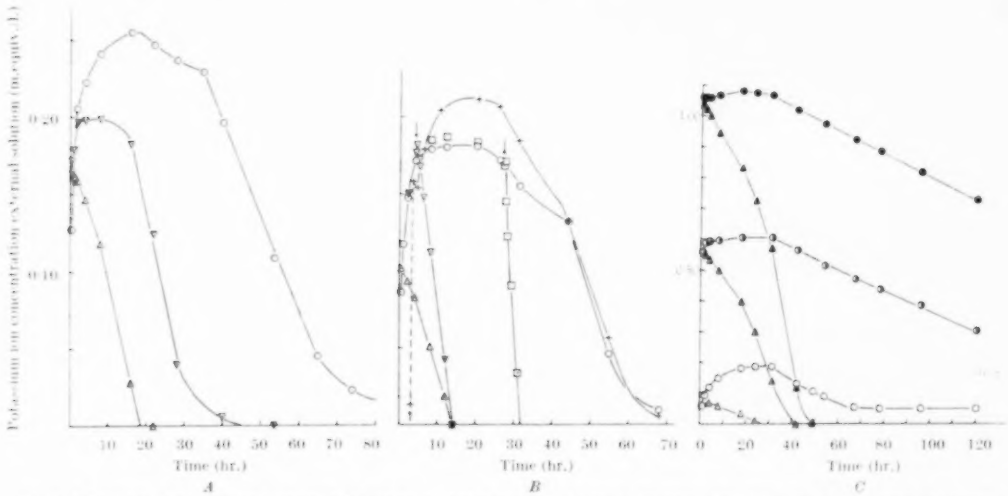

Fig. 1. *A*, *B* and *C*. Potassium ion content of the external solution (m.equiv./L) due to leaching and subsequent re-absorption of calcium ions by red beet slices. *A*: ○, distilled water *p*H 6·3–6·4; △, 10^{-2} *M tris* *p*H 7·9–8·0; ▽, 10^{-2} *M tris* *p*H 6·0–6·3. Temp. 20° C. *B*: ○, distilled water *p*H 6·2–6·5; △, 10^{-2} *M tris* *p*H 7·9–8·0; ▽, 10^{-2} *M tris*, 4 hr. from start of experiment, added as 7·5 ml. 2×10^{-1} *M* solution, *p*H 7·85–8·0; □, 10^{-2} *M tris*, 27 hr. from start of experiment, *p*H 8·0; +, 10^{-2} *M tris* for 2 hr., *p*H 8·0, followed by two rinses of ¼ hr. duration each (*p*H 6·7 and 6·1, respectively). 1 ml. 0·019 *M* potassium chloride added to make up for lost potassium ions during rinsing of tissue. Temp. 21–22° C. *C*: ○, distilled water, *p*H 5·55–6·15; △, 10^{-2} *M tris*, *p*H 7·80–7·95; ◗, $0·5 \times 10^{-2}$ *M* potassium chloride solution, *p*H 5·50–5·95; ▲, $0·5 \times 10^{-2}$ *M* potassium chloride + 10^{-2} *M tris*, *p*H 7·80–7·90; ●, 10^{-2} *M* potassium chloride, *p*H 5·50–6·00; ▲, 10^{-2} *M* potassium chloride + 10^{-2} *M tris*, *p*H 7·50–7·80. Temp. 23° C.

solution to drop to less than 10^{-6} *M*. With an average potassium ion concentration in the tissue of close to 10^{-1} *M*/kgm., this meant that under these experimental conditions accumulation ratios of 10^5 and more were observed for potassium ions, which is much higher than any of the values recently quoted and observed by MacDonald *et al.*[6].

When 10^{-2} *M tris* (*p*H 8·0, adjusted with hydrochloric acid) was applied, more potassium ions appeared in the external solution during the first half-hour; presumably *tris* ions replaced a proportion of the potassium ions in the Donnan free space. However, this was immediately followed by a rapid uptake at a linear rate.

When the *p*H of the *tris* solution was adjusted to 6·0–6·3, leakage continued over a longer period (up to 2 hr.), and *tris* was less effective in reducing the lag-phase. A very similar curve to that at *p*H 6·0–6·3 was obtained when *tris* was applied at 10^{-2} *M* and *p*H 8·0. *Tris* has a pK_a value of 8·14 (ref. 15), and is 98·6 per cent ionic at *p*H 6·3; assuming that the base of *tris* is more effective than its ionic form, the reduced effect of *tris* at *p*H 6·0–6·3 could be ascribed to the lowering of its effective concentration.

Tris added at 4 and 27 hr. respectively from the start of the experiment had an immediate and greatly accelerating effect on uptake apart from freeing some potassium ions of the Donnan free space during the first 10 min. (Fig. 1,*B*). In another treatment, disks were immersed for 2 hr. in *tris* and were then washed with two quick rinses in water. On replacement in water containing potassium ions, equivalent to the amount lost during the rinses, it can be seen (Fig. 1,*B*, curve – + –) that the effect of *tris* on the net influx was not maintained after the *tris* had been washed away.

It yet remained possible that part of the difference between *tris* and control treatments could be due to the presence or absence of suitable anions in the respective solutions. Hence, the results of an experiment in which either $0·5 \times 10^{-3}$ *M* or 10^{-2} *M* potassium chloride was added to the external solutions are presented in Fig. 1,*C*. It can be seen that the presence of an initial amount of potassium chloride had no effect on the length of the lag-phase, or on the rate of uptake in control solutions, while it substantially increased the rate of uptake in the presence of *tris*.

Sharp contrasts were provided by the effect of *tris* on the lag-phase of other tissues (Fig. 2). Although extremely effective on carrot and parsnip tissue, it had no such effect on artichoke, swede, potato and turnip

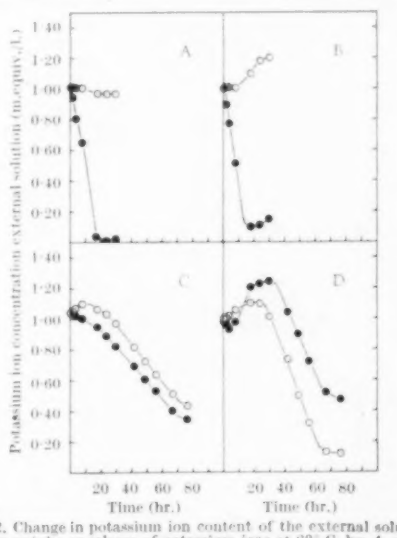

Fig. 2. Change in potassium ion content of the external solution, due to uptake or release of potassium ions at 23° C. by *A*, carrot phloem tissue; *B*, parsnip phloem tissue; *C*, artichoke tissue (*Helianthus*); and *D*, swede tissue. ○, disks in 10^{-2} *M* potassium chloride solution, *p*H 6·05–6·85, 6·00–6·70, 6·10–7·20 and 6·00–7·10 for *A*, *B* *C* and *D*, respectively; ●, disks in 10^{-2} *M* potassium chloride + 10^{-2} *M tris* solution, *p*H 7·65–7·95, 7·50–7·95, 7·85–8·00 for *A*, *B*, *C* and *D*, respectively

tissue. Hence, the effects of *tris* are quite specific, and in the case of beetroot, parsnip and carrot the characteristics of the molecule seem to fit certain requirements to make a rapid and immediate uptake of potassium ions possible.

Experiments with some readily available analogues of *tris* showed that the presence of OH-groups were essential for activity, *tris*, 2-amino-2-methyl-1 : 3-propanediol, 2-amino-2-methyl-1-propanol and 2-amino-2-methyl-propane (tertiary butylamine) form a series of declining activity (Fig. 3,*A*). In fact, tertiary butylamine had no effect on the lag-phase, and the slightly better intake of potassium ions over the distilled water treatment could have been partly due to the difference in *p*H of the solutions.

Triethanolamine and *tris* were equally effective, indicating that the nature of substituents rather than degree of substitution at the N-level was of prime importance, namely, triethanolamine was much more effective than ethanolamine while N,N-dimethyl-aminoethanol had no effect on the lag-phase (Fig. 3,*B*).

It was observed on an earlier occasion that the addition of 10^{-2} *M* calcium ions shortened the lag-phase to approximately 12 hr.[16]. This effect, rather remarkable in itself, could most probably be related to the so-called 'Viets' effect'[17], that is, the stimulation of potassium ion absorption by the presence of moderately high concentrations of calcium ions, which has received considerable attention, because of its rather paradoxical nature[18,19]. Because some relationship might exist between the shortening of the lag-phase induced by the presence of calcium ions and that induced by *tris*, experiments were carried out to study the interaction of these effects. Results presented in Fig. 3,*C* show unequivocally that the effect of calcium ions prevailed when disks were immersed in a mixture of 10^{-2} *M* calcium chloride and 10^{-2} *M tris*, while, on the other hand, additions of 10^{-5}–5×10^{-5} *M* ethylenediaminetetraacetic acid (EDTA) to the medium have consistently produced small but significant enhancements of the *tris* effect (Fig. 3,*C*). Hence, it is feasible that *tris* and calcium ions compete for a common site, the bivalent calcium ions being much more efficient in this respect than the univalent *tris* ions.

The mechanism of the *tris* and calcium effects cannot be defined at present at all closely. It has been shown that calcium ions are essential for membrane formation or maintenance[20], and there is little doubt that the calcium ion status of the membrane plays an important part in the characterization of its physical and chemical properties[21,22]. It would be premature to make a pronouncement whether *tris* operates as a carrier molecule, or indirectly exerts its influence through its adsorption to the membrane structure; however, the absence of a sustained effect when *tris* is removed externally, the fact that calcium ions also can have a shortening effect on the lag-phase, and that *tris* and calcium may compete for a common site in that respect, make the second alternative more likely at present. In the presence of *tris*, accumulation ratios for potassium ions were of the order of 5×10^5, the highest ever observed. Hence, it appears that *tris* caused such change as to facilitate the approach and incorporation of potassium ions from the external solution into the membrane. For example, if a carrier operated across the plasmalemma, it could only be effective as such when the active part of the molecule is exposed at the external side of the membrane. The presence of *tris* may condition the membranes in such a way, possibly through the unfolding or swelling of proteinaceous material[23,24], as to facilitate this exposure. According to Klotz and Ayers[23] suggestions, the latter effect would increase with an increase in *p*H.

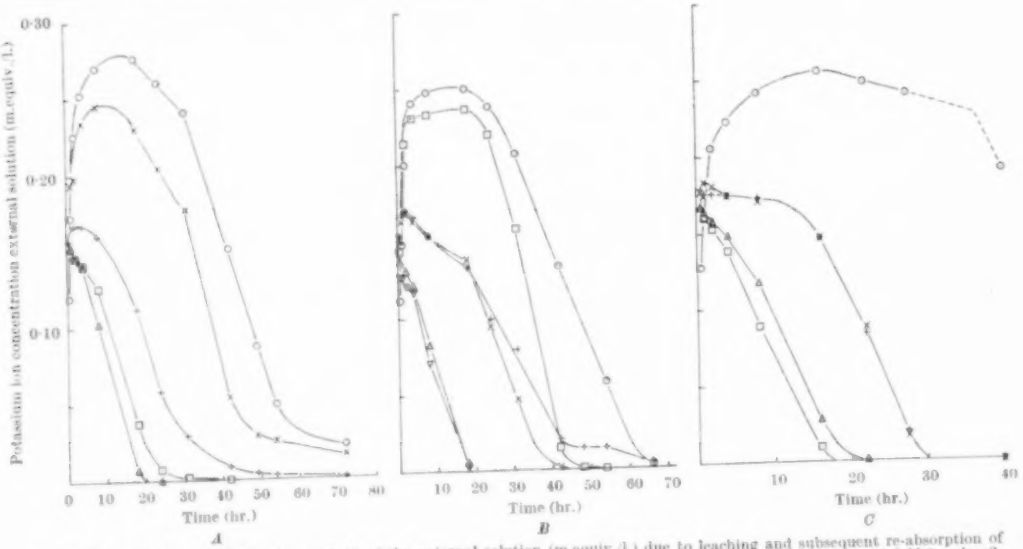

Fig. 3 *A*, *B* and *C*. Potassium ion content of the external solution (m.equiv./l.) due to leaching and subsequent re-absorption of potassium ions by red beet slices at 24° C. *A*: ○, distilled water, *p*H 6·35–6·70; △, 10^{-2} *M tris*, *p*H 8·20–8·35; □, 10^{-2} *M* 2-amino-2-methyl 1 : 3 propanediol, *p*H 8·05–8·30; +, 10^{-2} *M* 2-amino-2-methyl 1-propanol, *p*H 8·00–8·10, *p*H adjusted with base during the course of the experiment; ×, 10^{-2} *M* 2-amino-2-methyl propane (tertiary butylamine), *p*H 7·80–7·95, *p*H adjusted with base. *B*: ○, distilled water, *p*H 6·25–6·55; △, 10^{-2} *M tris*, *p*H 8·1–8·2; ▽, tri-ethanolamine 10^{-2} *M*, *p*H 7·8–8·2, *p*H adjusted with base during the experiment; □, N,N-di-methyl amino-ethanol 10^{-2} *M*, *p*H 7·8–8·0 (adjusted); ×, methyl amino-ethanol 10^{-2} *M*, *p*H 7·7–8·2 (adjusted); +, ethanolamine 10^{-2} *M*, *p*H 7·4–8·1 (adjusted). *C*: ○, distilled water, *p*H 6·3–6·4; △, 10^{-2} *M tris*, *p*H 7·9; +, 10^{-2} *M* calcium chloride, *p*H 8·0 → 7·0 → 7·5 (adjusted with saturated calcium hydroxide); ×, 10^{-2} *M* calcium chloride + 10^{-2} *M tris*, *p*H 7·8; □, 10^{-2} *M tris* + 10^{-2} *M* ethylenediaminetetraacetate, *p*H 7·9

The existing data[26–29] show little effect of *p*H on uptake of potassium ions between 6 and 8 except for Hurd's[29] results, which, however, apply to uptake in aged disks and which show stimulation of uptake at *p*H 8·5. Hurd's results did show the importance of HCO_3 with aged disks, and he regarded *tris* as an indifferent buffer, which is certainly not true for uptake during the lag-phase.

The present results do not support the views that leaching of inhibitors or of cations are pre-requisites for ion-uptake. Nor do they suggest that accumulation of carrier molecules in metabolism is essential.

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PHAGOCYTIC ACTIVITY IN SQUAMOUS EPITHELIA AND ITS ROLE IN CELLULAR SUSCEPTIBILITY TO FOOT-AND-MOUTH DISEASE

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EXPERIMENTAL foot-and-mouth disease in the guinea pig is characterized by epithelial necrosis, and sometimes vesiculation, of squamous epithelium in certain rather sharply localized regions of the body, of which the buccal mucosa, the prepuce and the hairless parts of the feet are the most consistently involved[1]. Skin-grafting experiments have indicated that the mild environmental trauma to which these sites are constantly exposed plays an important part in rendering them susceptible to the virus, and that it probably does so principally through some direct effect on the epithelial cells[2]. Since this might be effected by an influence on the cell membranes, a study has been made in guinea pigs of the response of squamous epithelial cells in the skin and tongue to inert particles. The purpose of the present article is to report the marked phagocytic activity of injured epithelium, and its relevance to the distribution of lesions in foot-and-mouth disease.

The animals used were albino guinea pigs, weighing 500–600 gm., housed and maintained as previously described[3]. The metatarsal pads, palmar pads of the fore-feet, outer surface of the ear, skin of the flank and margin of the prepuce were inoculated intradermally with 0·02–0·05-ml. volumes of particulate suspensions, or tattooed with a sewing needle through a drop of the material on the epithelial surface. In the metatarsal pads, and in grafts of pad on the chest, injections were made via longitudinal intra-epithelial tracks. Injection of the tongue was done under nembutal anæsthesia, and inocula (0·02–0·05 ml.) were introduced into the corium underlying the dorsal epithelium via the lower surface of the tongue. The materials injected were: (1) indian ink (G. T. Gurr, Ltd.); carbon particle size < 0·5–2·0μ; this was heated for 5–10 min. at 100° before use; (2) a 5 per cent suspension of lamp-black (prepared by combustion of benzene) in reconstituted guinea pig serum; particle size < 0·5–6·0μ; (3) suspensions of ground carmine in reconstituted guinea pig serum; particle size 0·5–3·0μ; (4) saccharated iron oxide ('Colliron'; Evans Medical Supplies, Ltd.). This was injected as a clear solution. In each case, an equal volume of hyaluronidase was usually added (final concentration 75–125 turbidity-reducing units/ml.) but it was not essential. The animals were killed 6–18 hr. later, and their tissues were excised, fixed in 10 per cent neutral formalin or in carnoy, embedded in paraffin wax and sectioned at a thickness of 6μ. Sections were stained with hæmatoxylin and eosin for demonstration of carbon, with hæmatoxylin alone for carmine, or with Perl's method for saccharated iron oxide.

In all sites, a proportion of epithelial cells around the needle tracks had usually phagocytized the inert particles. The reaction was most marked in the apparently undamaged cells surrounding the zone of traumatized and necrotic tissue produced by the needle and sometimes cells up to $\frac{1}{2}$ mm. from the edge of this zone contained particles. Cells from the basal layer to the upper part of the stratum spinosum showed an apparently equal capacity for phagocytosis. The amount of material engulfed varied considerably, from occasional cytoplasmic particles, often lying near the nucleus, to dense aggregates forming nuclear caps (Figs. 1 and 2). All the materials were taken up to some extent but the cells appeared to phagocytize the indian ink and saccharated iron oxide rather more readily than the other suspensions. Intra-epithelial injections in the metatarsal pads were frequently accompanied by some hæmorrhage from the dermal capillaries and, in several instances,

free erythrocytes had entered the intercellular spaces of the viable epithelium around the track and been phagocytized by cells of the stratum spinosum. Some cells contained both inert particles and erythrocytes.

At the periphery of some of the inoculation sites (hairy skin, prepuce, fore-feet), where the inoculum was in contact with the basal layer remote from the needle track, cells containing particles were very much rarer. They were mostly basal cells with occasional prickle cells. In the tongue dorsum, there was marked phagocytosis by local basal and spinous cells in areas of the epithelium inadvertently damaged during inoculation, but when the suspensions were injected without epithelial damage, no phagocytosis was found.

These results demonstrate that squamous epithelial cells under the influence of local trauma are capable of considerable cell surface activity. This probably arises through activation of their amœboid mechanisms under the influence of reparative stimuli and local loss of contact inhibition[3,4]. The phagocytic activity of the epithelial cells is thus a reflexion of their cell-membrane instability.

These findings are relevant to the pathogenesis of foot-and-mouth disease, and also possibly other virus diseases in which mild traumatization plays a part in the initiation of infection[5]. In the epithelium of the mouth, feet and other sites, where continual low-grade trauma is experienced, cell-membrane

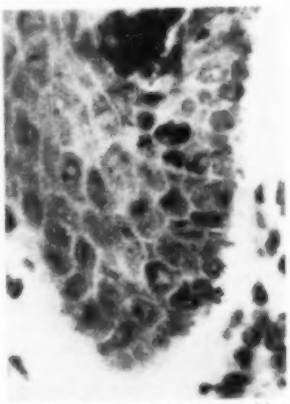

Fig. 1. Metatarsal pad: showing a rete peg with a needle track containing indian ink (above), and phagocytosis of carbon particles by local epidermal cells (hematoxylin and eosin. × 500)

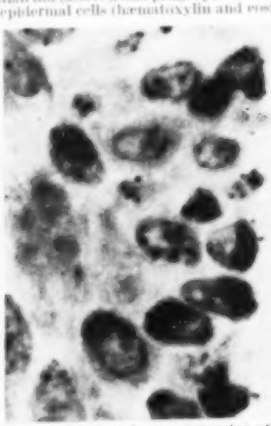

Fig. 2. As Fig. 1: showing dense aggregates of carbon in epidermal cells of a rete peg (× 1,220)

Fig. 3. Metatarsal pad: phagocytized erythrocytes (arrowed) and carbon granules in epidermal cells (hematoxylin and eosin. × 900)

instability is likely to be present in some degree. In addition, the dislocation of intercellular contacts resulting from the mechanical stresses to which these epithelia are exposed may also be expected to increase cell-membrane activity, since cells not making good all-round contact display more active pinocytosis[6]. In regions where these conditions exist therefore, the squamous epithelial cells are more likely to take up small particles such as viruses non-specifically, and the degree of stimulation needed for this may be much less than is required for the uptake of relatively gross particles such as carbon, for which an actual wound appears to be necessary. It is likely, therefore, that the distribution of lesions in foot-and-mouth disease is partly attributable to enhanced cell-membrane activity at the predilection sites, thus facilitating the entry of the virus into the local cells.

The ability of the virus to multiply after cellular penetration presumably depends on highly specific cytochemical conditions within the host cell. In this respect, the cells at the predilection sites appear to provide a more favourable environment for multiplication of the virus than elsewhere in the skin. Thus, injection of foot-and-mouth disease virus directly into the hairy skin of the flank, or into pad grafts on the chest, produces only minimal lesions[1,2], yet the present experiments indicate that virus thus injected would be taken up by local epidermal cells around the puncture. The failure to develop typical lesions suggests that these cells are metabolically insusceptible. The cytochemical conditions necessary for multiplication of foot-and-mouth disease virus are unknown, but it is relevant that cells exhibiting active pinocytosis will take up more nutrients and fluid than their less-active neighbours[6]. Reparative influences may also play some part in determining metabolic patterns favourable to multiplication of the virus in areas of skin and mucous membrane exposed to persistent traumatization.

I wish to thank Messrs. J. R. P. Dale and R. R. H. Hill for their valuable assistance in the course of this work.

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THE NUCLEOLUS

Formation of the Nucleolus in Animal Cells

IN most animal cells the nucleoli disappear as visible entities during the early stages of mitosis and reappear in the daughter cells when mitosis is completed. The question arises whether the nucleolar material, which is for the most part protein, is synthesized *de novo* after mitosis, or whether it is dispersed at the beginning of mitosis without being degraded and reassembled when mitosis is at an end. In the present article an experiment is described which partially resolves this question for one cell type: the connective tissue cell of the rat.

Dispersed cultures of connective tissue cells were prepared from rat hearts and cultivated in small coverslip chambers[1]. If such cells are incubated for 30–60 min. in medium containing tritium-labelled valine and autoradiographs of the fixed preparations are made, the nucleoli in almost all the cells can be seen to be heavily labelled. (Tritium-labelled valine was prepared by an exchange reaction between tritium gas and the vapour of an ethyl ester of valine on a platinized platinum electrode at 50° C.[2]. The purified compound had a specific activity of 1·5 c./m.-mole.) It has been shown that in these cells exogenous valine is not converted to any significant extent to other compounds but is incorporated almost entirely into the valine residues of protein[3]. The autoradiographs therefore reflect the distribution of radioactive valine which has been incorporated into the proteins of the cell. Amino-acids incorporated in this way are released only very slowly over several days and thus form a relatively stable label for protein. When cells which had been incubated in the presence of radioactive valine are transferred to non-radioactive medium containing unlabelled valine, the specific activity of the valine in the free amino-acid pool of the cells falls within half an hour to negligible levels. Therefore, if cells which have been exposed to tritium-labelled valine are transferred to non-radioactive medium containing unlabelled valine and incubated in this medium until they have all undergone mitosis, autoradiographs of the daughter cells should show unlabelled nucleoli if the nucleolar protein is synthesized *de novo* from free amino-acids immediately after mitosis, and labelled nucleoli if the reappearance of these structures after mitosis involves the aggregation of material which was synthesized earlier.

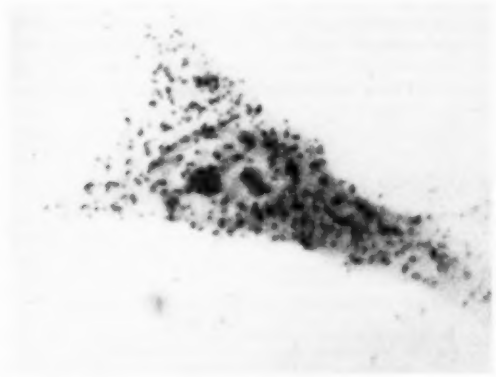

Fig. 1. Autoradiograph of a connective tissue cell incubated for 1 hr. in medium containing tritium-labelled valine. Note the heavy labelling over the nucleoli

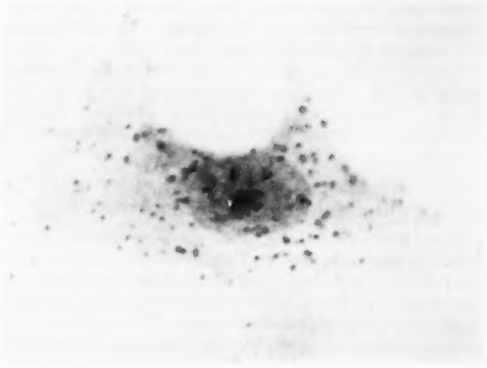

Fig. 2. Autoradiograph of a connective tissue cell from a culture incubated for 1 hr. in medium containing tritium-labelled valine and then for 40 hr. in non-radioactive medium. The nucleolus is still heavily labelled relative to the rest of the cell

The following experiment was undertaken. Replicate cultures of connective tissue cells were incubated for 1 hr. in medium containing tritium-labelled valine at a concentration of 5 μc./ml. At the end of this period some of the preparations were fixed in methanol and then extracted with 0·3 *N* trichloroacetic acid at 90° C. for 30 min. Autoradiographs of the fixed extracted cells were made by the usual stripping-film technique and developed after 3 days. Fig. 1 shows an autoradiograph of a cell from one of these preparations; it will be noted that the nucleoli are heavily labelled.

Other preparations were washed repeatedly with physiological saline after the period of incubation in radioactive medium and then incubated for 40 hr. in non-radioactive medium containing L-valine at a concentration of 5 m.*M*. The mean generation time of the cells under these conditions was about 24 hr., so that by the end of 40 hr. almost all the cells would have passed through at least one mitosis. The preparations were then fixed and extracted with trichloroacetic acid. Autoradiographs were made and were again developed after 3 days. Examination of these autoradiographs showed that in the great majority of the cells the nucleoli were still heavily labelled relative to the rest of the cell, and unlabelled nucleoli were very rare. Fig. 2 shows an autoradiograph of a cell from a culture incubated for 1 hr. in radioactive medium and then for 40 hr. in non-radioactive medium.

This finding eliminates the possibility that all the nucleolar protein is formed *de novo* from free amino-acids immediately after mitosis. The ratio of the mean number of grains over the nucleoli to the mean number over the rest of the nucleus shows no great change during the 40-hr. cultivation in non-radioactive medium, thus indicating that the nucleolar

proteins are not broken down and resynthesized at a rate very different from the rest of the proteins in the nucleus. The reappearance of nucleoli at the end of mitosis must therefore involve the aggregation into a visible structure of proteins which were synthesized before mitosis. The present experiment does not, of course, demonstrate that these proteins are necessarily derived from the pre-mitotic nucleoli, but this does seem to be a likely possibility.

HENRY HARRIS

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Evidence for the Continuity of Nucleolar Material in Mitosis

In a previous article[1] evidence is presented that in pollen grains of maize and agave, basic protein of the pre-mitotic nucleolus was divided without loss, but unequally, between the nucleoli of the resulting vegetative and generative cells. These experiments were repeated in another species and extended to include measurements on the ribonucleic acid (RNA) and the dry mass of the nucleolus. The species studied was *Strelitzia reginae* Banks, which has large pollen grains easily divested of their walls. Each nucleus has only one nucleolus and this is large (about 7μ in diameter at prophase) and not obscured by the relatively small amount of chromatin.

Measurement of Dry Mass. Anthers in which there were both pre- and post-mitotic pollen grains were fixed in acetic-alcohol (1 : 3) for 6 hr. and stored in 70 per cent alcohol at 4° until required. 2-mm. segments of anther were treated by the method of Warmke[2] and squash preparations of the pollen grains were made in 45 per cent acetic acid. With this treatment the walls of the pollen grains were separated from the contents, which could then be flattened. Photometric measurement of azure *B*-binding[3] in sectioned material indicated that the treatment in Warmke's solution did not remove a significant amount of RNA from the nucleoli. The coverslips with the squash preparations were then floated off in distilled water, rinsed twice, mounted in distilled water on other slides and ringed with rubber solution. Each preparation was examined and the positions of all cells suitable for measurement—those which were intact, flat, not folded and not obscured by debris—were noted. In all such cells the path differences of the nucleolus or nucleoli were measured at 5460 Å. with the Baker interference microscope.

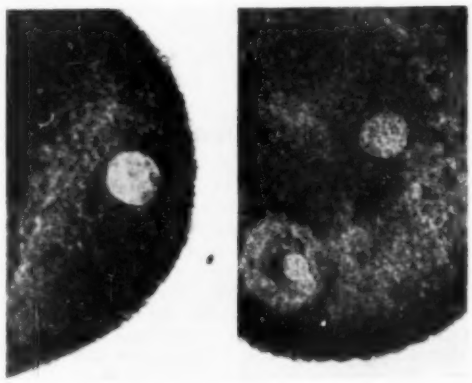

Fig. 3. Pollen grains of *Strelitzia reginae* divested of their walls, flattened and photographed through the Baker interference microscope to show nucleoli. Left, pre-mitotic; right, post-mitotic with vegetative nucleolus top, generative nucleolus bottom (× 550)

The blank reading was made on an area immediately adjacent to the nucleolus. Typical cells are shown in Fig. 3. Cells on which measurements were made were photographed, and the areas of the nucleoli were computed with a planimeter on a drawing of the projected image of the negative.

The coverslips were then floated off the slides and, because cells adhered to the slides and the coverslips, both were treated with ribonuclease at 35° for 3 hr. (0·2 per cent (w/v) in distilled water at *p*H 6). The ribonuclease (L. Light and Co.) was free from protease activity as judged by its failure to release free amino-acids from serum albumen. The slides and coverslips were washed and mounted separately in distilled water. In order to make it easier to find the cells again, the coverslips were placed on fresh slides in the same relative positions as they had occupied on the slides from which they had been removed. Path differences and areas were again measured. The preparations were then stained with azure *B*. Complete absence of stain in the nucleoli confirmed the effectiveness of the ribonuclease.

Results were obtained from two experiments and, because they did not differ significantly, they have been combined in Table 1. There is good agreement between the measurements on the two post-mitotic nucleoli for the total dry mass and the reduction in dry mass resulting from treatment with ribonuclease. It appears that in all three types of nucleoli, RNA

Table 1. MEANS AND STANDARD DEVIATIONS OF MASSES (GM. × 10^{-12}) OF NUCLEOLI IN 45 PRE-MITOTIC AND 23 POST-MITOTIC POLLEN GRAINS

Nucleolus	No.	Total dry mass	Removed by RNA-ase	Remaining after RNA-ase	Mean percentage removed by RNA-ase
Vegetative	23	115 ± 33	26 ± 13	89 ± 31	22·9
Generative		29 ± 10	6 ± 4	23 ± 9	22·3
Sum of veg. + gen.		144 ± 39	32 ± 15	112 ± 35	
Pre-mitotic	45	145 ± 29	33 ± 19	112 ± 25	22·4

Table 2. MEANS AND STANDARD DEVIATIONS OF AMOUNTS OF STAIN IN ARBITRARY UNITS (WHICH ARE DIFFERENT FOR EACH STAIN) IN NUCLEOLI BEFORE AND AFTER POLLEN GRAIN MITOSIS

Nucleoli	Azure *B*		Fast green	
	No. of cells	Amount	No. of cells	Amount
Vegetative	30	84·4 ± 11·8	16	35·3 ± 6·0
Generative		20·0 ± 4·9		9·1 ± 2·5
Veg. + gen.		104·4 ± 13·0 } 0·6 > *P* > 0·5		44·4 ± 6·0 } 0·2 > *P* > 0·1
Pre-mitotic	30	102·0 ± 15·9	13	41·2 ± 6·5

accounts for about 22 per cent of the dry mass after fixation (95 per cent fiducial limits of the mean are 20·2 and 24·8 per cent).

Measurement of Basic Protein and Ribonucleic Acid. An anther from the same bud as that used in the previous experiments was fixed in 10 per cent neutral formalin, washed overnight, embedded and sectioned at a thickness of 15μ. The sections were heated in water at 90° for 10 min.[4] and then incubated for 2 hr. at 35° in 0·1 per cent (w/v) deoxyribonuclease. They were then stained in azure *B* bromide by the method of Flax and Himes[3], which is thought to be specific for RNA. The sections were differentiated until nucleoli were the only densely stained cell constituent and then mounted in thick cedarwood oil. Positions of all cells suitable for measurement—those in which the nucleoli were not cut or obscured—were noted. Measurements were made on the cells seriatim across the slide until 30 pre-mitotic and 30 post-mitotic nucleoli had been measured. The amount of stain in each nucleolus was measured at 5050 Å. with an integrating microdensitometer[5]. The blank reading was made on an area immediately adjacent to the nucleolus. The coverslip was then removed, and the slides were hydrated (and destained in the process). They were then stained with fast green *FCF* by the method of Alfert and Geschwind[6], which is thought to be specific for basic protein. During this procedure about half the cells were lost. In those remaining, the amount of stain in the nucleoli was measured at 5800 Å. (The photomultiplier was not sensitive at 6280 Å., the absorption maximum.) The results are shown in Table 2.

Again, the sum of the values for the two post-mitotic nucleoli does not differ significantly from the value in the pre-mitotic nucleolus.

Measurements were made on the amounts of azure *B* and fast green *FCF* in thirteen pre-mitotic nucleoli, and a correlation was found between the amounts of the two dyes bound ($r = 0{\cdot}663$, $0{\cdot}01 < P < 0{\cdot}02$). A similar correlation was found in measurements on sixteen vegetative nucleoli ($r = 0{\cdot}694$, $0{\cdot}01 > P > 0{\cdot}001$), but in sixteen generative nucleoli, which were considerably smaller and more difficult to measure accurately, a significant correlation was not detected because of the magnitude of the errors of measurement. A possible interpretation of this correlation is that the two stains reflect different components of what, in the intact cells, is a single structural entity, for example, ribonucleoprotein.

The demonstration by interferometry that the sum of the dry masses, after fixation, of the post-mitotic nucleoli was equal to the dry mass of the pre-mitotic nucleolus makes it possible to test the validity of an independent method of estimating a nucleolar component. For example, the fact that the amount of azure *B* bound by the two post-mitotic nucleoli together was statistically equal to the amount bound by the pre-mitotic nucleolus tends to confirm the specificity of the staining procedure and also the validity of the method of estimation. Further evidence that the different methods yield similar results is obtained from a comparison of the ratio of the mean values for the vegetative nucleoli to the mean values for the generative nucleoli. In the interferometry experiments the ratio was 3·98 for total dry mass, 4·02 for the mass removed by ribonuclease and 3·97 for the remainder; in the photometry experiments it was 4·22 for azure *B* and 3·88 for fast green *FCF*.

The results presented here give support to the view that the nucleolar material is not degraded during mitosis, but simply dispersed and re-assembled. If the nucleolar material were degraded and then re-synthesized, rather complex regulatory mechanisms would have to be postulated to explain the fact that the total amount of material in the two post-mitotic nucleoli, although these differ in size, is equal to the amount in the pre-mitotic nucleolus. In the light of the autoradiographic results reported in the preceding article, the simplest and most plausible explanation is that a substantial part of the nucleolar material maintains a structural continuity throughout mitosis. It is, of course, possible that only one component of the nucleolus, for example, protein, remains intact and that the amounts of other components, for example, ribonucleic acid, are regulated by the amount of protein present.

This work was carried out during the tenure of a Nuffield Dominion travelling fellowship at the John Innes Institute. I wish to thank Mr. L. S. Clarke for assistance with photography. I am particularly indebted to Mr. L. F. LaCour and Dr. J. McLeish for their expert advice.

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HUMAN HÆMOGLOBIN A_2: CHEMISTRY, GENETICS AND EVOLUTION

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THE normal individual has at least three types of hæmoglobin. In fœtal life and in early infancy he has a specific fœtal hæmoglobin (*F*). Within a few months of birth this hæmoglobin has been replaced by adult hæmoglobin (*A*), together with a small proportion of another hæmoglobin (A_2)[1]. This hæmoglobin A_2 normally amounts to about 2·5 per cent of all hæmoglobins; however, in many instances of thalassæmia minor the proportion is doubled. We wish to report briefly the results to date of chemi-

cal studies of hæmoglobin A_2 which shed light on the possible role in thalassæmia of this form of hæmoglobin and on its evolution.

Hæmoglobin A_2 is readily distinguished from the major adult component (A) by its characteristic electrophoretic mobility ; it moves with the abnormal hæmoglobin E at pH 8·6 and pH 6·5 (ref. 1). Like hæmoglobin E, hæmoglobin A_2 shows the same unusual shift in relative electrophoretic mobility at the two pH values. At pH 8·6, hæmoglobin A_2 is close to hæmoglobin C, while at pH 6·5 it is relatively slower and moves close to hæmoglobin S.

Kunkel *et al.*[2] showed that A_2 is truly a separate hæmoglobin and not a chemical derivative of hæmoglobin A. In the ultracentrifuge, hæmoglobins A and A_2 could not be distinguished[2], which implied that their molecular weights are similar ; their spectra in the visible and ultra-violet were also indistinguishable[2]. As a result, the only difference which could be found between the hæmoglobins A and A_2 was their electrophoretic mobility, in contrast to hæmoglobin F, which differs from hæmoglobin A in its ultra-violet spectrum[3] as well as in electrophoresis[4].

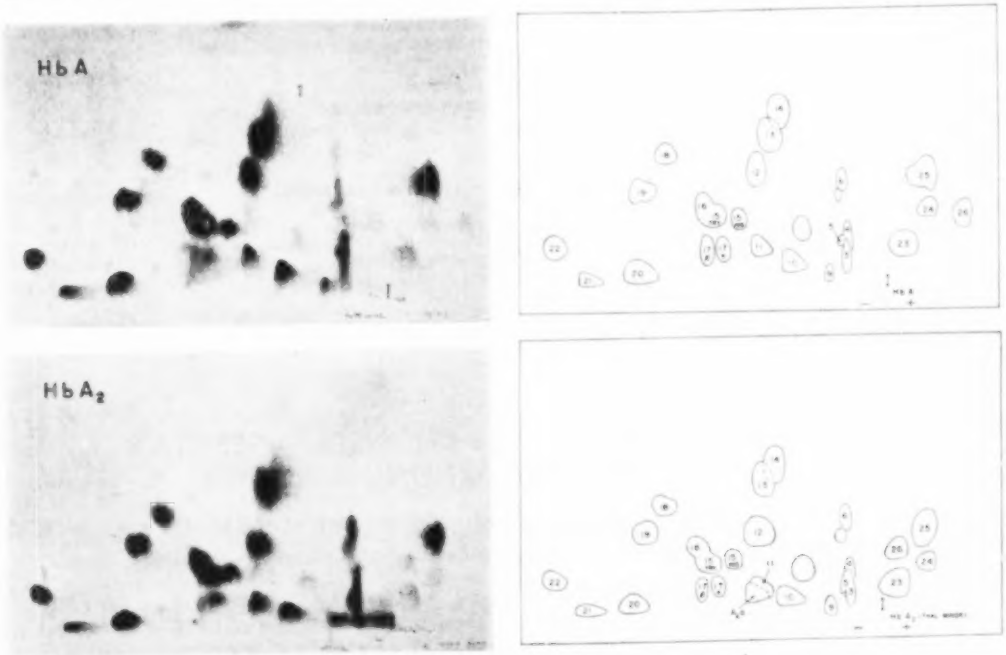
Characteristically, hæmoglobin F differs also from A in having four *iso*leucine residues per molecule[5], an amino-acid notably absent from A. Our quantitative amino-acid analysis on the Spinco model Moore and Stein automatic analyser of carefully purified hæmoglobin A_2 showed the absence of *iso*leucine ($< 0·2$ residues per molecule). This finding is in contrast to the report by Rossi-Fanneli *et al.*[6], who recently published analyses of hæmoglobin A_2 containing > 6 residues of *iso*leucine per molecule. However, their preparation of hæmoglobin A_2 involved fewer purification steps than ours and might be contaminated with the non-hæm-containing protein known to have an electrophoretic mobility similar to hæmoglobin A_2.

Fingerprinting of Hæmoglobin A_2

Hæmoglobin A_2 was prepared from normal blood and from the blood of people with thalassæmia minor. The hæmoglobin solution from washed cells was carefully freed from stromal material by centrifugation at 30,000g at 2° C. Hæmoglobin A_2 was obtained by starch-block electrophoresis in 0·06 M veronal buffer pH 8·6 followed by adsorption on a short column of carboxymethyl cellulose in 0·01 M phosphate buffer at pH 7·0. The non-hæm protein is not adsorbed under these conditions, and could therefore be separated from the hæmoglobin. The hæmoglobin was eluted with 0·2 M phosphate buffer at pH 7·0 or with 0·06 M veronal buffer at pH 8·6. After dialysis, the hæmoglobin A_2 was submitted for a second time to starch-block electrophoresis, eluted, and reconcentrated on carboxymethyl cellulose. The protein was dialysed against 0·001 M phosphate buffer, pH 7·0, before use.

Comparison of hæmoglobin A_2 with A was made in the first instance by fingerprinting[7,8] tryptic digests of the two proteins (Fig. 1). In what follows a peptide will be named as follows: tryptic peptide number 26 (ref. 7) from hæmoglobin A is 'peptide AT-26'; similarly, peptide A_2T-26 is peptide number 26 from tryptic digests of hæmoglobin A_2, and so forth.

Several differences have been found in the fingerprints: the same peptide AT-26 in which hæmoglobin E differs from A (ref. 9) has an amino-acid substitution in hæmoglobin A_2 also ; a glutamic acid residue has been replaced by alanine in peptide A_2T-26 (Fig. 2). However, determination of the amino-acid sequence of peptide A_2T-26 showed that



a *b*

Fig. 1. Fingerprints (refs. 7, 8) of tryptic digests of hæmoglobins A and A_2: *a*, photograph; *b*, tracing

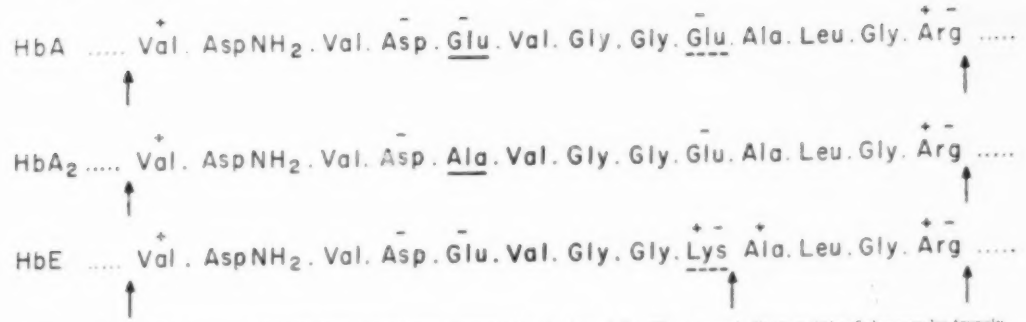

HbA ..... Val. AspNH2. Val. Asp. Glu. Val. Gly. Gly. Glu. Ala. Leu. Gly. Arg .....
HbA2 ..... Val. AspNH2. Val. Asp. Ala. Val. Gly. Gly. Glu. Ala. Leu. Gly. Arg .....
HbE ..... Val. AspNH2. Val. Asp. Glu. Val. Gly. Gly. Lys Ala. Leu. Gly. Arg .....

Fig. 2. Amino-acid sequences of tryptic peptide 26 from hæmoglobins A, A_2 and E. The arrows indicate points of cleavage by trypsin

it was the first or the two glutamic acid residues of peptide AT-26 which had changed to alanine. In hæmoglobin E it is the second glutamic acid which is replaced by lysine[9].

Another difference between the fingerprints of hæmoglobins A and A_2 is found in the peptides AT-12 and A_2T-12, which have the same electrophoretic mobility but differ in behaviour during chromatography. Peptide A_2T-12 is definitely slower. This difference was confirmed by the technique of dissected fingerprints[10]. The quantitative amino-acid composition of the two peptides, determined as above, was as follows: AT-12: $Ser_1,Thr_1,Gly_1,Ala_2,Val_1,Leu_1,Lys_1$; A_2T-12: $Asp_1,Thr_1,Gly_1,Ala_2,Val_1,Leu_1,Lys_1$. The basic nature of peptide A_2T-12 at pH 6·4 suggests that the aspartic acid residue is in the amide form. Both peptide AT-12 and peptide A_2T-12 also contain tryptophan, but this is destroyed on acid hydrolysis. As expected, the difference did not involve a charged amino-acid, but seemed to indicate a replacement of serine by asparagine. However, end-group determination by the dinitrophenol-procedure[11] showed that the situation was more complex than had been realized. Peptide AT-12 gave serine and peptide A_2T-12 gave threonine as N-terminal amino-acids. Clearly, we are dealing here with two substitutions, serine → threonine and threonine → asparagine. Further experiments on the sequence of the two peptides are in progress.

Examination of peptide AT-25 and A_2T-25 showed a further amino-acid difference. These peptides are indistinguishable in paper electrophoresis; a slight chromatographic difference was observed, when the isolated peptides were compared by paper chromatography in butanol/acetic acid/water (4 : 1 : 5). Amino-acid analysis of the peptides AT-25 and A_2T-12, carried out as above, showed a threonine (AT-25) to serine (A_2T-25) change in this nonadecapeptide. It is remarkable that such a small difference, involving a single methyl group in a peptide of molecular weight of more than 2,000, should show at all in chromatography. No further studies have yet been made on peptides AT-25 and A_2T-25 to determine whether this substitution is the only one in the peptide.

Finally, there is an additional peptide, A_2a. To date, the peptide of hæmoglobin A, which corresponds to the tetrapeptide A_2a, has not been found in spite of a careful search. Many other tryptic peptides of A_2 have been analysed quantitatively and found to be similar to their hæmoglobin A analogues (Table 1). The peptides examined account for at least 90 amino-acid residues, or about two-thirds of the δ-chain. Of these, only 4 or 5 amino-acids appear to be altered, as discussed above, assuming that for the rest similar amino-acid composition implies similar sequence.

Examination of the trypsin resistant 'core' of hæmoglobin A_2 by chymotryptic digestion and fingerprinting[13] suggested that the core might be different in several of its chymotryptic peptides. However, not all these differences were reproducible; although most of the 'core' fingerprint is similar for hæmoglobins A and A_2, the degree of similarity is by no means certain.

An important conclusion to be drawn from the present chemical studies is that the hæmoglobin A_2 from individuals with thalassæmia minor is indistinguishable from that of normal people, within the limits of the methods employed. Most of the analyses and sequences reported in this article were in fact made with thalassæmic hæmoglobin A_2, since this was less laborious to prepare. However, careful comparison of fingerprints and 'dissected fingerprints'[10] of hæmoglobin A_2 from normal and thalassæmic individuals gave us confidence that the two proteins are identical. Furthermore, if the thalassæmia hypothesis[14], discussed here, is correct, then the donor of the thalassæmic blood should be suffering from a β-chain thalassæmia, and the genes controlling his hæmoglobin A_2 would not be affected by this mutation.

We can summarize the chemical findings by saying that the tryptic fingerprints of hæmoglobins A and A_2 show four definite amino-acid substitutions and, in addition, the peptide A_2a.

The peptide chains of hæmoglobin A_2 were next separated to ascertain how these five differences are

Table 1. Comparison of Tryptic Peptides from the δ Chain of Hæmoglobin A_2 with those from the β Chain of Hæmoglobin A

Peptide No.*	No. of amino-acids present	No. of amino-acids found to be different in hæmoglobin A and A_2
		By amino-acid analysis
22	1	—
20	4	—
19	2	—
12	9	2
4	8	—
5	12	1 (?)
6	16	—
25	19	1
26	13	1
	By specific staining only†	
14	3	—
15	2	—
17	2	—
	90	4–5

* See ref. 7 for the numbering of peptides.
† Detecting only arginine, tyrosine, histidine, tryptophan and sulphur-containing amino-acids (ref. 12).

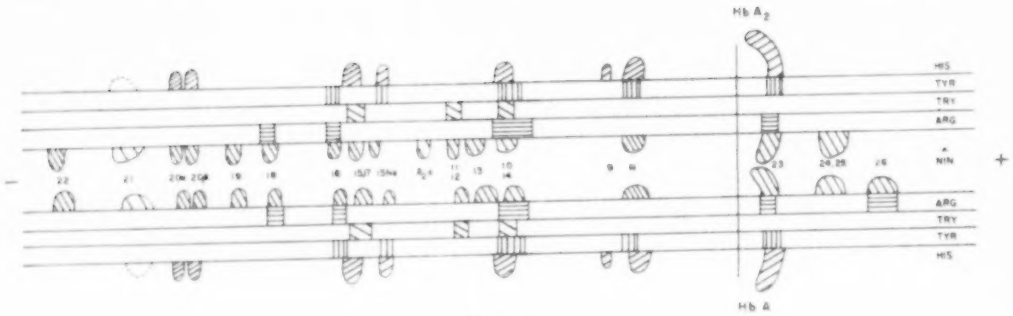


Fig. 3. One-dimensional electrophoresis at pH 6·4 and specific stains of tryptic digests of haemoglobins *A* and A_2

distributed between them. For this purpose, we used a small-scale modification of Hill and Craig's counter-current distribution technique[15], employed by them to separate the two types of peptide chain (α and β) of haemoglobin *A*. Hunt[16] had shown that in foetal haemoglobin, the molecule of which is written $\alpha_2^A\gamma_2^F$, the two α chains are similar, if not identical to the α chains of haemoglobin *A*—$\alpha_2^A\beta_2^A$. We find that none of the differences between haemoglobins A_2 and *A* is in the α chain, but they are confined entirely to the other type of chain of A_2. This chain should be called the δ[12] chain and the whole molecule, Hb$A_2 = \alpha_2^A\delta_2^{A2}$.

Genetic Control of Hæmoglobin A_2

The reasons for introducing the concept of separate δ chains in haemoglobin A_2 are several. The observed amino-acid substitutions are at least four in number and probably more numerous. This fact distinguishes these chains from the β chains of the series of abnormal human haemoglobins, such as the β^S chain of Hb *S* the β^C of Hb *C*, the β^E chain of Hb *E*, etc., all of which differ from the normal β^A chain of Hb *A* by a single amino-acid substitution[17]. On the other hand, the chemical similarity between β and δ chains is considerable as evidenced by the possession of the same *N*-terminal sequence Val.His.Leu . . .[18], by the same *C*-terminal sequence . . . Tyr.His[8], by the absence of *iso*leucine and by the apparent similarity in many tryptic peptides.

The necessity for their designation as 'δ chains' is confirmed by the genetic evidence that these chains are under genetic control which is separate from that of the β chain. For example, a mutation of the β gene, as in Hb *S* or Hb *E*, does not result in an altered δ chain; the haemoglobin A_2 component remains normal[2].

In addition, it appears that there is an independent series of alleles of haemoglobin A_2. Ceppellini[19] has discovered an abnormal minor component, haemoglobin B_2, which has a slower electrophoretic mobility than haemoglobin A_2. In individuals carrying the B_2 component, the proportion of A_2 is decreased from the normal 2·5 to 1·2 per cent, and B_2 is present in the same amount, that is, the sum of haemoglobins A_2 and B_2 is the usual 2·5 per cent. Furthermore, in individuals who also have thalassæmia, the level of A_2 and B_2 together was increased to 5 per cent, each being present at a level of 2·5 per cent.

Another abnormally slow A_2 component, described by Huisman and Meyering[20] as A_2', has an electrophoretic mobility which is similar to that of the haemoglobin B_2 mentioned above. In the family in which it was discovered, it was found always together with thalassæmia, and the sum of A_2 and A_2' was also elevated above the normal level of A_2.

Shooter *et al.*[21] have evidence that the α chains of haemoglobins *A* and A_2 are under the control of the same α gene. In a person homozygous for the abnormal haemoglobin G_{Ibadan}, which differs from haemoglobin *A* in the α chain[22], no normal haemoglobin A_2 was found. Instead there was a new minor component, G_2, which differed in electrophoretic mobility from haemoglobin A_2 in the same way that haemoglobin *G* differs from haemoglobin *A*.

We are, therefore, left to conclude that the genetic control of the production of haemoglobin A_2 is exercised by α and δ genes, whereas haemoglobin *A* is controlled by α and β genes. It appears[18], in addition, that the β and δ genes are linked. The haemoglobins of a normal individual are therefore under the control of four genes: α, β, γ and δ. The α gene is concerned in the manufacture of all three types of haemoglobin: $F = \alpha_2^A\gamma_2^F$, $A = \alpha_2^A\beta_2^A$, $A_2 = \alpha_2^A\delta_2^{A2}$. These various haemoglobins are produced depending on whether or not the β, γ or δ genes are 'active', which in turn seems to depend on the stage of development of the individual.

Hæmoglobin A_2 in Thalassæmia

The work of Kunkel *et al.*[2] and of Gerald and Diamond[23] has shown that haemoglobin A_2 is involved in some of the thalassæmia diseases, since in many instances the proportion of A_2 rises to about 5 per cent.

We have recently proposed a hypothesis[14] (and an alternative) which suggests that the thalassæmia mutations are similar to those which lead to the single amino-acid substitutions in the recognized abnormal adult haemoglobins (for example, Hb–*S*, *C*, *E*, etc.). However, thalassæmia is thought to differ from the abnormal haemoglobin diseases in that the proposed thalassæmia mutations lead to amino-acid substitutions which do not affect the electrophoretic mobility of the haemoglobin produced, but merely its rate of synthesis. An immediate consequence of this idea is the distinction of different thalassæmias as affecting either the α or the β chain of Hb–*A*. It has been suggested[24] that the occurrence of high proportions of foetal haemoglobin is compensatory in cases which we now describe as homozygous for a β chain thalassæmia. This could not happen for an α chain thalassæmia, since foetal haemoglobin uses α chains. Similarly, the observed rise of haemoglobin A_2 in some thalas-

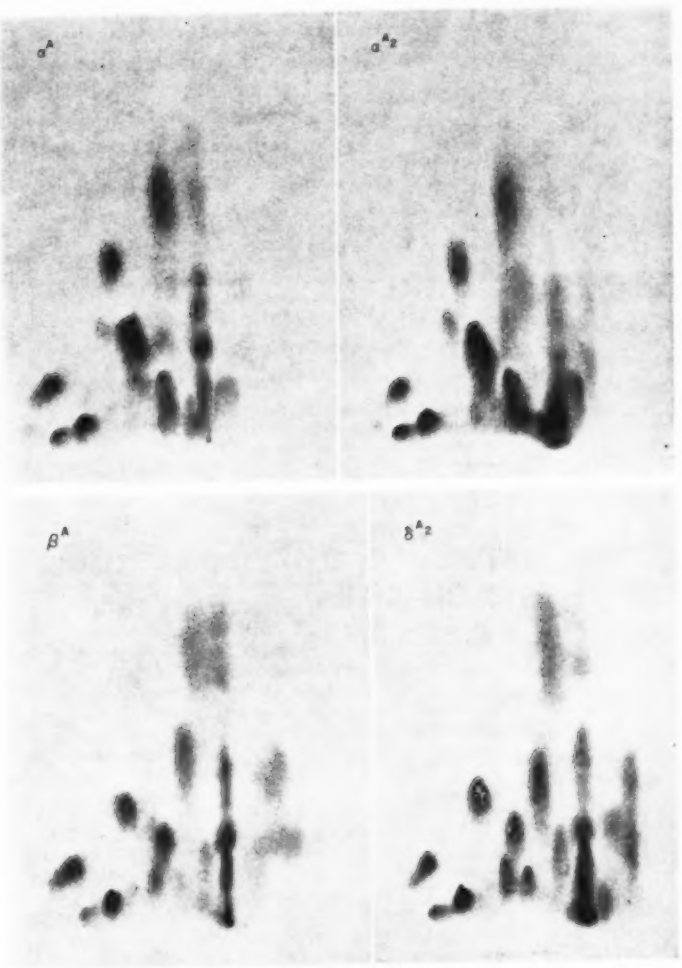


Fig. 4. Fingerprints of tryptic digests of: *a*, α chains of hæmoglobins *A* and A_2; the extra spots in the fingerprint of the α^{A_2} chain are known to be due to contamination with the δ^{A_2} chain; *b*, β chain of hæmoglobin *A* and δ chain of hæmoglobin A_2

saemia minors can be ascribed to the presence of a δ chain defect. In certain cases, this classification of the thalassæmia is borne out of a study of the pedigree[14]. Again, the cases of thalassæmia which do not have increased levels of A_2 (refs. 2, 25, 26) would be classified as α chain thalassæmias.

In the case of an α chain thalassæmia, a rise in hæmoglobin A_2 would not be expected since the relative rates of synthesis of β^A and δ^{A_2} chains should be normal. On the other hand, a β chain thalassæmia would decrease the rates of synthesis of the β^A chain relative to that of the δ^{A_2} chain, and therefore lead to an increase in the proportion of hæmoglobin A_2.

Evolution of Hæmoglobin A_2

Kunkel *et al.*[3] showed that blood specimens from cattle, horses, pigs, dogs and rabbits failed to show a minor component similar to A_2 hæmoglobin.

However, when they examined specimens from primates, in several cases a hæmoglobin A_2-like component was found. Ten chimpanzees showed such a component, comprising 2·4 per cent of the total hæmoglobin; the mobilities of the major and the minor components were indistinguishable from those of the human counterparts.

The New World monkey, *Cebus capucinus*, also showed the presence of A_2, but at levels of 4–5·5 per cent. No hæmoglobin A_2 was found in several Old World monkeys: *Macacus rhesus*, *M. cynomolgus* and *M. cercopithecus*.

The absence of A_2 in the Old World monkeys is at first sight surprising, since they are often held by zoologists to be more advanced than the New World monkeys. However, it might be that the particular examples studied were exceptions, which had lost the A_2 component during evolution. If all Old World monkeys lack A_2, perhaps this can be taken as a taxonomic criterion, along with the anatomical criteria at present used.

It would be of interest to extend this survey to other primates, to see whether the presence or absence of A_2 has a phylogenetic significance, as is suggested by these preliminary studies. Among the apes, the gibbon, orang-utan and gorilla have yet to be examined. An examination of primitive races of humans, such as aborigines, would also be of interest in this respect.

Although, on the basis of the limited survey that has been made, the A_2 component appears to be confined to the primates, other animal species are known to possess more than one hæmoglobin component. For example, it is possible that the two horse hæmoglobins[27] are related in a similar way as are the human hæmoglobins A and A_2.

A satisfactory explanation of the system of genetic control of hæmoglobin A_2 is that comparatively recently in evolution the β gene underwent duplication and that the two genes evolved independently from the original type by mutation to give the presently existing β and δ genes[28]. Gene duplication has been demonstrated in *Drosophila* both by genetic analysis and by cytological investigation of salivary chromosomes (for example, the 'bar' duplication)[29].

A process of duplication followed by divergence has long been considered by geneticists as a possible mode of origin of new genes[30]. While cases of duplication are known, no instance of subsequent independent evolution has been reported. It is believed that hæmoglobin A_2 provides an illustration of this process and that it furnishes evidence as to the way in which genes evolve.

We wish to thank Dr. Park Gerald for supplies of thalassæmic blood and for stimulating discussions.

This work was supported by a grant from the National Science Foundation. One of us (A. O. W. S.) thanks the National Institutes of Health for a fellowship under a training grant.

Addendum. Muller and Jonxis[21] have recently discussed their fingerprints of haemoglobins *A* and A_2. Although there is a large measure of agreement between their results and ours, our results differ in that we find no arginine in the neutral tyrosine-containing peptide 5 (which they denote as peptide 2). Also, we find the additional peptide A_2a, which they do not report.

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ESTIMATION OF PERCENTAGE NATURAL CROSS-POLLINATION : EXPERIMENTS ON RICE

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IN work on the amount of cross-pollination which occurs under natural conditions in crop plants, the term 'percentage cross-pollination' has not always been clearly defined; consequently it is not always easy to assess the meaning of some of the published values. In many cases this is because the nature of the experimental design used has made it impossible to give a simple definition. Percentage cross-pollination is defined here as the number of seeds produced by all the plants in a plot—excluding those plants at the edge—which are the result of a cross-pollination, expressed as a percentage of the total number of seeds produced by those plants. Our definition of cross-pollination is the fertilization of one plant by another. (Fertilization of one flower by another on the same plant can be considered as self-pollination from the genetical and practical point of view.)

The basis of our design is as follows. Two pure-line varieties are used which have the same duration from sowing to flowering and are similar in most other respects (such as height, tiller number, etc.) except for one character which is genetically dominant in one variety and recessive in the other. We used the rice variety *BG*79, which has a red-pigmented leaf-sheath in the seedling stage (dominant), and Lead 35, which has a green leaf-sheath (recessive). The two varieties are planted as shown in Fig. 1. Assuming that the chance of cross-pollination is the same between plants at the same distance, an examination of Fig. 1 (see also Table 1) shows that any plant has an equal chance of being cross-pollinated by either variety when the eight nearest plants to it are considered. When plants farther away than the nearest eight are considered, it may be assumed that the chance of cross-pollination is less, but the chance of either variety effecting this is still approximately the same. (No information is available concerning the relationship between distance and the chance of cross-pollination; but if one makes the assumption that pollen dispersal is comparable to certain forms of spore dispersal[1], then the chance of cross-pollination would be inversely proportional to the square of the distance; if this is so, then the chance of cross-pollination in any plant near the centre being caused by any plant of the same variety as against any plant of the other variety is approximately 0·485 : 0·515.)

When the plot is ripe, a number of plants of the variety which has the recessive character is gathered from the centre of the plot (in Sierra Leone we chose the nine plants included in the central square shown in Fig. 1). The seed (F_1) from these plants is grown and the number of plants showing the dominant and recessive character noted. Those showing the dominant character provide an estimate of half the number of cross-pollinations which took place.

The main disadvantage inherent in this design is due to the fact that plants with the same character are aligned in rows. In Fig. 1, if the top of the

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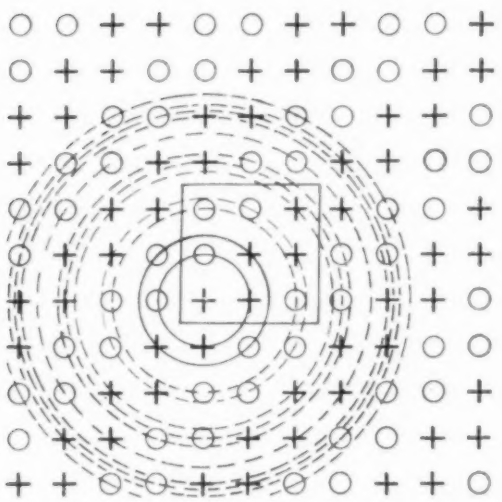

Fig. 1. Planting diagram of cross-pollination experiment. Each small circle represents a plant with the dominant character and each cross represents a plant with the recessive character. Concentric circles have been described round one of the 'recessive' plants to demonstrate those plants which are equidistant from it for the twelve innermost circles of plants. In the immediate neighbourhood of the central plant (solid circles), there is an equal number of each variety equidistant from it

page is considered as north, these lines run from south-west to north-east. Because of this alignment, directional factors are likely to distort the result. (This criticism also applies to a number of popular designs such as those based on a chess-board pattern.) For example, if wind is an important agent for carrying pollen then a prevailing south-westerly or north-easterly wind at the time of pollination would result in an underestimate of the amount of cross-pollination taking place, whereas a wind at right-angles to this would result in an overestimate. However, this apparent disadvantage can be made use of providing replicate trials are laid down with the diagonal rows of plants orientated at right-angles to one another. Such replication should compensate for any directional influences; furthermore, comparison of the differently orientated trials should give an indication as to whether directional influences are important.

Table 1. Distribution of Plants of each Variety around any given Plant near the Centre of the Design, showing the Number of Plants of each Variety and their Distances from the given Plant

The circles 1–12 referred to in the first column are shown in Fig. 1

Position of circle of plants numbering from the innermost outwards	Radius of circle (that is, distance of plants from the central plant) in feet	No. of plants on circumference of circle	
		Same variety as central plant	Different variety from central plant
1	1·00	2	2
2	1·41	2	2
3	2·00	0	4
4	2·24	4	4
5	2·83	4	0
6	3·00	2	2
7	3·16	4	4
8	3·61	4	4
9	4·00	4	0
10	4·12	4	4
11	4·24	2	2
12	4·47	0	8
13	5·00	6	6
14	5·10	4	4
15	5·38	4	4
16	5·66	4	0
17	5·83	4	4
18	6·00	0	4
19	6·08	4	4
20	6·32	8	0
21	6·40	4	4

We have carried out experiments on rice at two sites near the coast of West Africa—at Rokupr (9° 01′ N., 12° 57′ W.) in Sierra Leone and at Koba (9° 55′ N., 14° 04′ W.) in Guinea. One experiment was carried out at Koba and two at Rokupr within the normal season but planted on different dates. At Koba 75 out of the 14,021 seedlings in the F_1 were found to have a red leaf-sheath; this gives a value of 1·07 per cent cross-pollination. At Rokupr, 1 red leaf-sheath out of a total of 5,210 seedlings was obtained in the first experiment and 1 out of 5,004 in the second. As these results at Rokupr are very similar, they have been grouped together to give a value of 0·04 per cent cross-pollination.

These experiments indicate that the percentage natural cross-pollination in rice in West Africa is low but may vary considerably under different environmental conditions.

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PRIMARY METABOLIC DEFECT SUPERVENING ON VITAMIN B_{12} DEFICIENCY IN THE SHEEP

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Résumé of Experimental Findings which led to the Present Investigations

WHEN the concentration of cobalt within the paunch contents of a sheep falls below 40 mμgm. cobalt/gm. (20 μμgm./ml. of the bacteria-free supernatant) a manifest change occurs in the nature of the delicately poised associative growth of micro-organisms which constitutes the rumen flora. Although the rate and course of fermentation of carbohydrates within the rumen remain unaltered by this change, production of vitamin B_{12} and its analogues by the newly established microbial population decreases very materially. In such circumstances, bacterial synthesis of vitamin B_{12} itself falls precipitately from the level of 600–1,000 μgm./day, which normally prevails in the presence of adequate cobalt, to less than 50 μgm./day.

As the efficiency of absorption of the vitamin B_{12} produced by the rumen micro-flora is not more than

3 per cent, the amount of the vitamin that becomes available to the animal's tissues at this lower level of production is insufficient to make good the normal metabolic wastage of the functional vitamin B_{12}-containing complexes. Depletion then ensues.

The sheep suffers no obvious impairment of its physiological function until its complement of the vitamin as indicated by the concentration of vitamin B_{12} in its liver is reduced below 0·15 μgm. vitamin B_{12}/gm.

This is a critical level; depletion beyond it results in a marked loss of metabolic efficiency. The animal, then, can deal no longer with the fermentation products arising from a full feed; its appetite fails progressively as depletion proceeds, food consumption reflecting with remarkable precision the extent of the diminishing vitamin B_{12}-status, until death from inanition supervenes.

At any stage of the syndrome, provision of adequate vitamin B_{12} arrests further decline and dramatically restores normal health.

In the search for this defect of intermediary metabolism, the fact that a shortage of vitamin B_{12} imposes a much more profound metabolic stress on ruminants than on other animals, prompted the experiments reported here.

Unlike other animals, the ruminant derives the major part of its energy requirements from acetic and propionic acids produced by fermentation of the carbohydrates of its fodder. The course of this fermentation is remarkably consistent. The relative concentrations of the volatile fatty acids present in the rumen contents of our experimental sheep vary somewhat, but not greatly, throughout the 24-hr. cycle of rumination. The molecular ratios of the three main fatty acids present in the rumen contents 4 hr. subsequent to feeding are typical. At this stage, acetic acid comprises about 57 per cent, propionic acid 27 per cent and butyric acid 13 per cent of the total volatile acids; the remaining 3 per cent is made up of traces of formic, *iso*butyric and higher acids arising from secondary fermentations of other substrates.

The earliest of our investigations of the metabolic efficiency with which a sheep deals with individual fatty acids injected into its bloodstream demonstrated, unequivocally, that a state of vitamin B_{12}-deficiency seriously impairs the animal's capacity to utilize propionic acid, whereas its capacity to utilize formic and acetic acids remains unchanged.

Normal capacity to catabolize acetic acid becomes reduced occasionally in sheep that have been confined for two years or more to cobalt-deficient rations supplemented by parenteral injection of vitamin B_{12}, and then induced to become vitamin B_{12}-deficient by removal of the supplement. In these very rare cases, a massive parenteral dose of folic acid immediately reinstates normal metabolic function in this respect, leaving unaltered the seriously impaired capacity to metabolize propionic acid as the primary consequence of uncomplicated vitamin B_{12}-deficiency.

The site of the metabolic disability imposed in animal tissues by vitamin B_{12}-deficiency was located, unequivocally, by our work on the relative capacities of homogenates from the livers of normal and of vitamin B_{12}-deficient sheep to effect the catabolism of propionate. The metabolic defect is in the pathway of transformations, described by Flavin and Ochoa[1], through which, in animal tissues, propionate is launched into the Krebs cycle. Precisely, the breakdown arises from failure of the transfer reactions responsible for the intermediate isomeric conversion of methyl malonyl co-enzyme-A to succinate.

Tagging of the functional vitamin B_{12}-containing component by injection of cobalt-58 vitamin B_{12} into deficient sheep facilitated its isolation from their livers. This complex functions as a co-enzyme essential for the conversion of methyl malonate to succinate.

Finally, we have shown this co-enzyme to be identical with the 5:6-dimethyl-benziminazole cobamide co-enzyme separated from the cells of micro-organisms. We are very grateful to Dr. H. A. Barker, Department of Biochemistry, University of California, and to Dr. D. Perlman, Squibb Institute for Medical Research, New Brunswick, for gifts of crystalline 5:6-dimethyl-benziminazole cobamide co-enzyme prepared respectively from the cells of *Clostridium tetanomorphum* cultured in media containing free 5:6-dimethyl-benziminazole, and from *Propioni-bacterium shermanii*.

Our latter experiments were influenced and facilitated by the work of Barker *et al.*[2], on the isomeric conversion of L-glutamate to α-L-β-methyl-aspartate by *Clostridium tetanomorphum*, a transformation shown by them to be dependent normally on a co-enzyme which contains the analogue, Pfiffner's ψ vitamin B_{12} (adenyl cobamide).

Whatever its action *in vitro*, the adenyl cobamide co-enzyme is unlikely to function in animal tissues either in the isomeric conversion of methyl malonate to succinate, or in the metabolism of glutamic acid, which latter takes a course entirely different from that in *Clostridium tetanomorphum*. The animal organism either rejects vitamin B_{12}-analogues or destroys them after absorption. The total vitamin B_{12}-activity in the tissues of a sheep, for example, is due to vitamin B_{12} itself, although very considerable quantities of its analogues are produced along with it in the rumen contents.

Whether the 5:6-dimethyl-benziminazole cobamide co-isomerase present in animal tissues is specific only for the transfer reactions involved in the conversion of methyl malonate to succinate is a moot point, however. Whereas the main symptoms of the vitamin B_{12}-deficiency syndrome in the sheep may be attributed unquestionably to the impairment of propionate metabolism, there are subsidiary symptoms that occasionally become evident, especially in long-standing cases of partial deficiency. Outstanding among these are a blood dyscrasia due to a reduced capacity to mature the red cells, and, on occasions as a terminal symptom, a fatty infiltration of the liver, attributable to an impairment of methionine metabolism. Both could arise from partial failures to translocate single carbon atoms, processes dependent either on the vitamin B_{12}-containing methyl malonate co-isomerase or upon similar vitamin B_{12}-containing complexes essential in other transfer reactions. In some of these, folic acid is involved.

The megaloblastic anæmia, which in sheep is a frequent, though not invariable, symptom of vitamin B_{12}-deficiency, responds spectacularly to treatment with either vitamin B_{12} or folic acid, as it does in the human malady, Addisonian pernicious anæmia. Vitamin B_{12} completely reinstates normal metabolic function; in the sheep, apart from reinstating normal erythropoiesis, folic acid has no effect on the course

of the deficiency syndrome which progresses to its fatal termination irrespective of the improved oxygen-carrying capacity of the blood.

Details of the experimental work upon which the above outline is based will be submitted for publication elsewhere. Those conducted, *in vivo*, which demonstrated the primary disturbance in the vitamin B_{12}-deficient sheep to be an impaired capacity to metabolize propionic acid, were referred to in the eleventh Annie B. Cunning Lecture delivered to the Royal Australasian College of Physicians in July 1958 (ref. 3). The studies, *in vitro*, which revealed the origin of this disability to be in the intermediary conversion of methyl malonate to succinate, and proved the dependence of this isomeric change on a vitamin B_{12}-containing co-isomerase, were reported in a section of the Tercentenary Exhibition of the Royal Society in July 1960. The following résumés are of some of our findings which concern directly the function of vitamin B_{12} in animal tissues.

H. R. MARSTON

Demonstration, *in vivo*, of the Site of the Metabolic Defect

As the volatile fatty acids are well tolerated, even when injected in considerable quantities into the blood stream; as the sheep's kidney threshold for them is high; and as equilibrium is quickly established between their concentrations in the blood and in the extra-cellular fluids, the criterion adopted to assess the effect of vitamin B_{12}-deficiency on the animal's metabolic efficiency in respect to them was the rate of their disappearance from the circulation after increasing materially their concentration by infusing their sodium salts into the jugular vein.

The best recommendation for this simple approach is the nature of the information it provided. The findings led directly to recognition of the metabolic defect that supervenes on vitamin B_{12}-deficiency.

Merino sheep were employed as experimental animals. They were confined in metabolism cages and fed on cobalt-deficient fodder which provided adequate nutrition in all respects other than the supply of vitamin B_{12}, which was considerably short of normal requirements. In the course of other experiments, we have determined that about 1·5 μgm. vitamin B_{12}/day is absorbed by sheep consuming the full ration (*cf.* legend to Fig. 6 for its composition). A sheep confined to this fodder loses close to 7·5 μgm. vitamin B_{12}/day in the normal course of its metabolism. Thus the overall deficit in these circumstances is about 6 μgm./day.

In some of the determinations, sheep of virtually the same age, size and previous nutritional history were selected and pair-fed. One of each pair was treated, parenterally, with abundant vitamin B_{12}, and its food intake restricted each day to that of the other animal, which was allowed to become depleted over the course of 35 or more weeks until it was in an advanced stage of the deficiency syndrome (Fig. 1). In other determinations, the effects were assessed by measurements made before and after the administration of massive amounts of vitamin B_{12} to deficient animals, food intake being regulated at a constant level during the short (4–7 days) interval between the tests. As vitamin B_{12} status was the only variable, both series of observations provided critical comparisons.

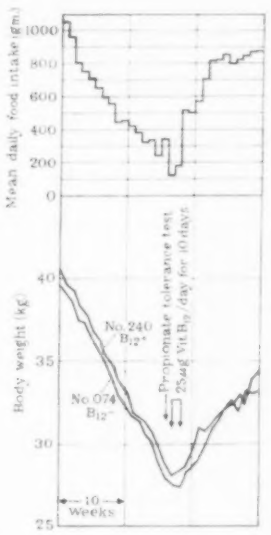

Fig. 1. Performance of pair-fed sheep
The performance of ewes No. 240 B_{12}^+ and No. 074 B_{12}^- used for the experiment illustrated in Fig. 4 is typical of that of the pairs referred to in Figs. 2 and 3. Food consumption of No. 240 was restricted throughout to that of No. 074

For each test, 3·5 m.mol. of the particular fatty acid per kgm. body-weight of the animal fasted for 24 hr., neutralized with sodium hydroxide and diluted to 1 molar concentration, was warmed to 38° C. and transfused steadily over the course of 5 min. into the blood stream via a fine plastic tube implanted temporarily into one of the external jugulars. A series of blood samples was collected at intervals through this tube, and the volume of the blood withdrawn replaced with physiological saline. Coagulation was prevented by washing the tube thoroughly with a solution of 1 : 10^5 heparin in physiological saline between each operation. Volatile fatty acid was determined in aliquots of the tungstic acid filtrates by constant-volume distillation and micro-titration in a stream of nitrogen. Gas–liquid partition chromatography was employed to determine the nature of the volatile acids in the blood.

The results from repeated overall determinations were within a very small experimental error, and left little doubt of the consistency of the underlying phenomena which they reflected. Those reported here are typical.

When raised artificially to abnormally high levels in the blood stream, simple fatty acids rapidly establish equilibrium with the *milieu interieur*, and afterwards their concentrations decrease exponentially to the low levels which normally prevail in the circulation of the fasting sheep.

The rate of this fall in the concentrations of formic acid (Fig. 2) and of acetic acid (Fig. 3), measured in this way, is unaffected by vitamin B_{12}-deficiency, even when the uncomplicated deficiency syndrome has progressed to its terminal stages. The metabolic capacity of the sheep to deal with propionic acid, however, is manifestly impaired by a state of vitamin B_{12} deficiency (Fig. 4). A significant decrease of this function is detectable even in the early stages of the deficiency syndrome, and thereafter it becomes progressively worse as depletion proceeds. Throughout

the course of the supervening syndrome the extent of this defect correlates closely with the diminishing vitamin B_{12} status of the animal's tissues.

We conclude, therefore, that vitamin B_{12} is an essential constituent of the enzyme system which constitutes the intermediary channel through which propionic acid passes in normal metabolism.

In ruminants, which, of necessity, deal with relatively large quantities of propionic acid, this metabolic consequence of vitamin B_{12}-deficiency is particularly serious. In the mixed-feeders it is also important, for these animals have to deal with considerable quantities of propionic acid derived from caecal fermentation of refractory carbohydrates that escape hydrolysis and absorption in the upper levels of the alimentary canal. Moreover, catabolic utilization of protein adds to this. The metabolic degradation of the amino-acids from 100 gm. of wheat gluten, for example, yields 4·1 gm. of propionic acid, which arises as an intermediary product in the degradation of the glucogenic amino-acids, L-valine and L-*iso*leucine.

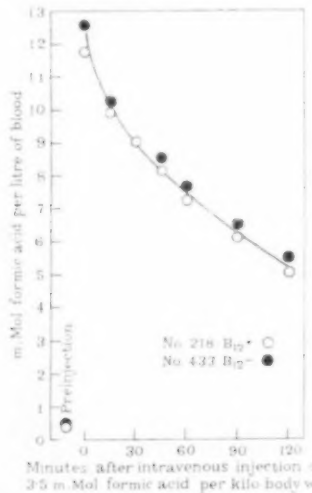
m Mol formic acid per litre of blood
Preinjection
No. 218 B12+
No. 433 B12−
Minutes after intravenous injection of 3·5 m Mol formic acid per kilo body wt.

Fig. 2. Lack of effect of vitamin B_{12}-deficiency on the metabolism of formic acid

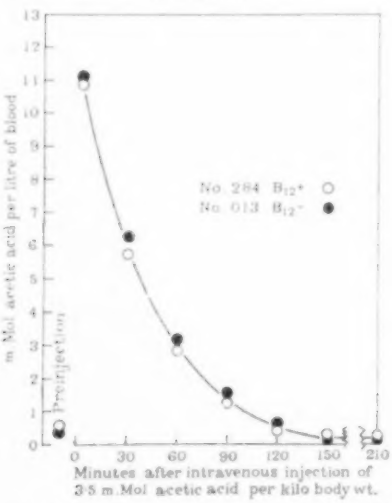
m Mol acetic acid per litre of blood
Preinjection
No. 284 B12+
No. 013 B12−
Minutes after intravenous injection of 3·5 m Mol acetic acid per kilo body wt.

Fig. 3. Lack of effect of vitamin B_{12}-deficiency on the metabolism of acetic acid

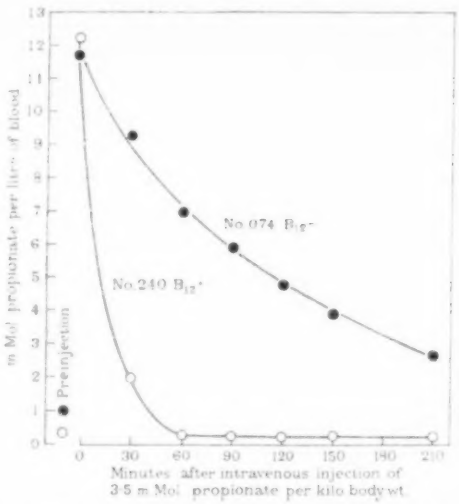
m Mol propionate per litre of blood
Preinjection
No. 074 B12−
No. 240 B12+
Minutes after intravenous injection of 3·5 m Mol propionate per kilo body wt.

Fig. 4. Effect of vitamin B_{12}-deficiency on the metabolism of propionic acid

The metabolic defect briefly discussed here has been reported[1] as an integral part of a comprehensive investigation of the effects of cobalt deficiency on Merino sheep.

S. H. Allen
H. R. Marston
R. M. Smith

Localization, *in vitro*, of the Metabolic Defect, and Separation of the Vitamin B_{12}-containing Methyl Malonyl Co-isomerase

If provided with carbon dioxide, adenosine diphosphate, and extra cytochrome *c*, homogenates of the livers of normal sheep, prepared to ensure that the mitochondria remain intact, metabolize propionate at approximately the same rate as malate and succinate. Under identical conditions (cf. legend to Table 1) homogenates, prepared in this way from the livers of vitamin B_{12}-deficient sheep, retain their ability to deal with malate and succinate but lose their ability to deal with propionate. Within the small experimental error of the observations, propionate added as a substrate remained unaltered, and there was no increase in oxygen consumption (Table 1).

The capacity of homogenates from deficient livers to metabolize propionate, *in vitro*, however, is strikingly different when the mitochondria are fragmented. Such homogenates, prepared to ensure liberation of the mitochondrial enzymes into the reaction mixture, readily convert propionyl coenzyme *A* to methyl malonyl coenzyme *A* if provided with carbon dioxide and adenosine triphosphate. In these circumstances, methyl malonyl coenzyme *A* accumulates (Fig. 5 (*a*)). Addition of the vitamin B_{12}-containing coenzyme, isolated (*vide infra*) from the livers of normal sheep, reinstates the capacity to effect the isomeric conversion of this intermediate, and as the efficiency of the Krebs cycle is reduced by dispersal of its enzymes in the reaction mixture, succinate accumulates (Fig. 5 (*b*)).

Table 1. METABOLISM OF PROPIONATE, MALATE AND SUCCINATE BY HOMOGENATES PREPARED FROM LIVERS OF NORMAL AND VITAMIN B_{12}-DEFICIENT SHEEP UNDER CONDITIONS IN WHICH THE MITOCHONDRIA REMAIN INTACT

Rate of propionate consumption, μequiv./mgm. N/hr.

Normal livers		Vitamin B_{12}-deficient livers	
Exp. No.		Exp. No.	
17	2·1	18	0·3
23	2·0	19	0·6
25	2·2	29	0·0
27	2·7	28	0·0
29	1·6	30	0·0
31	3·0	33	0·0
35	2·7	36	0·5
Mean	2·4	Mean	0·2

Rate of oxygen consumption, μl. O_2/mgm. N/hr.

Exp. No.	No substrate	Propionate	L-Malate	Succinate
Normal livers				
25	48	100	103	168
26	27	60	83	125
27	28	76	85	125
35	50	110	120	173
Mean	36	87	98	148
Vitamin B_{12}-deficient livers				
28	60	44	125	223
30	54	63	130	—
33	54	45	—	218
36	—	40	98	164
Mean	56	48	118	202

The liver homogenates used in the above experiments were prepared in 0·25 molar sucrose immediately after slaughter of the sheep. Nuclei and larger particles of cell debris were removed at 600 *g* for 10 min. The reaction mixtures comprised: potassium phosphate buffer *p*H 7·4, 2×10^{-2} *M*; sodium bicarbonate, $2{\cdot}5 \times 10^{-2}$ *M*; potassium chloride, $9{\cdot}0 \times 10^{-3}$ *M*; adenosine triphosphate, $1{\cdot}3 \times 10^{-3}$ *M*; cytochrome *c*, $1{\cdot}1 \times 10^{-6}$ *M*; added substrate, 5×10^{-2} *M*; sucrose added in homogenate about 4×10^{-2} *M*. The mixture, 5 ml., plus 0·5 ml. homogenate (2–3 mgm. nitrogen) was equilibrated in Warburg vessels with 95 per cent oxygen and 5 per cent carbon dioxide, which remained as the gaseous phase, then 0·5 ml. of substrate was added from the side arm. The reaction, at 37° C. for 36 min. with rapid shaking, was terminated by addition of tungstic acid. Volatile acid was estimated in the protein-free filtrate by micro-titration of the distillate in a rapid stream of nitrogen. Oxygen consumption was measured by Warburg's indirect method.

The site of the impairment of propionate metabolism is indicated by the failure of the liver homogenate from the vitamin B_{12}-deficient sheep to effect efficiently the conversion of propionate to succinate. This metabolic defect, which, as illustrated in Fig. 5 (*a*), leads to an accumulation of the intermediate, methyl malonyl coenzyme *A*, is made good (Fig. 5 (*b*)) by the addition of a vitamin B_{12}-containing methyl malonyl co-isomerase, isolated from the livers of sheep (*vide infra*). The experimental conditions were essentially as follows.

The homogenate, from the liver of the cobalt-deficient sheep, *A*7–507 (Fig. 6) was prepared in *tris*-hydroxymethylamino-methane buffer under conditions which fragment the mitochondria and disperse their constituents into solution.

Reaction mixture (*a*) comprised propionyl coenzyme *A*, 10^{-3} *M*; *A*7–507 liver homogenate (containing 1·53 mgm. protein); magnesium ions, adenosine triphosphate and glutathione, the whole buffered at *p*H 7·4, *tris*-buffer 0·05 *M*. Two μc. of $^{14}CO_2$ in 10 μmol. carbon dioxide were distributed between the solution and the gas phase above it. Total volume of reaction mixture, 1 ml. Incubated at 30° C. for 20 min.

Reaction mixture (*b*) was identical with (*a*), but contained in addition 5×10^{-7} *M* co-isomerase isolated from the livers of normal sheep. Volume and treatment as above.

At the end of the incubation period, the coenzyme *A* thioesters were hydrolysed with 0·2 ml. 2 *N* potassium hydroxide. The reaction mixture was then adjusted to *p*H 2·0 with sulphuric acid, carrier acids were added, and the whole exhausted with ether. The ether extract was taken to dryness, the residue dissolved in a drop of water and chromatographed on Whatman No. 1 paper with *iso*amyl alcohol saturated with 4 *N* formic acid.

The tracings of radioactivity by a scanning device (Fig. 5) are roughly comparable in arbitrary units.

The critical quantitative determinations of radioactivity due to $^{14}CO_2$ in each spot, reported there as c.p.m. observed, were effected by cutting round the spots developed by brom-phenol blue, and igniting the disks in a combustion furnace from which the whole of the effluent gases was transferred to a high-vacuum manifold essentially of the type described by Glascock[12]. Therein the total carbon dioxide was isolated and, after diluting with the requisite volume of inactive carbon dioxide and the addition of carbon disulphide, transferred quantitatively into a Geiger tube and total radioactivity estimated by modern scaling instruments. Determinations effected by this sensitive procedure are accurate and strictly comparable.

Under the same conditions, homogenates, prepared by this method from the livers of normal sheep, metabolize propionyl coenzyme *A* more readily to succinate without additional co-isomerase, the rate of clearance of the intermediate, methyl malonyl coenzyme *A*, depending on the concentration of co-

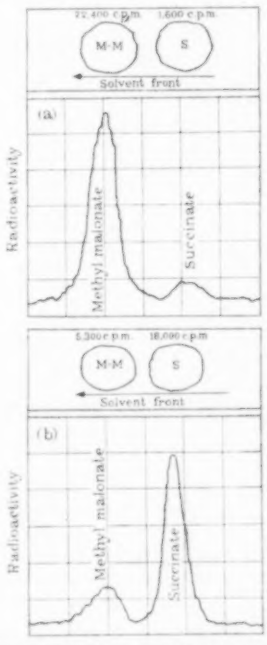

Fig. 5. Influence of added methyl malonyl co-isomerase on the metabolism of propionate by a homogenate from the liver of sheep *A*7–507 (Fig. 6) prepared to ensure fragmentation of the mitochondria. Reaction mixtures (*a*) and (*b*) were identical, other than the addition of 5×10^{-7} *M* co-isomerase to (*b*). The accumulation of methyl malonate in (*a*) indicates the metabolic lesion. For details see text

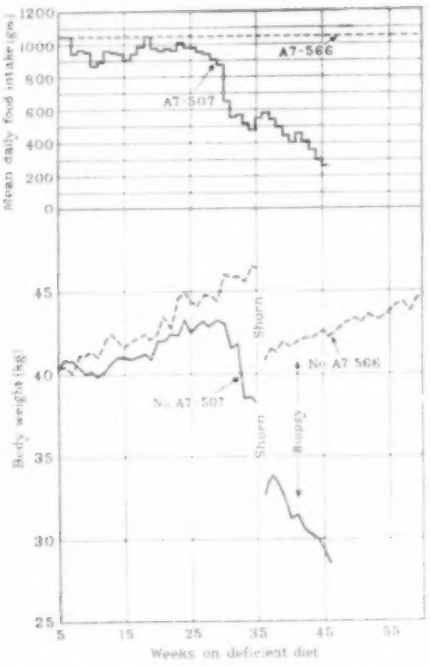

Fig. 6. Course of the vitamin B_{12}-deficiency syndrome in sheep A7-507

Criteria employed to assess the state of deficiency of sheep A7-507 were: failure of appetite, and the concentration of vitamin B_{12} in the liver and blood.

This animal and its control, A7-566, which was treated with adequate cobalt *per os*, were confined in pens and offered each day a cobalt-deficient ration composed of 1 kgm. of chaffed wheaten hay plus 50 gm. of gluten; the mixed fodder contained 0·023 μgm. cobalt/gm. The control animal avidly consumed the whole of the ration throughout. The appetite of the unsupplemented animal, unsteady after 8 weeks, failed progressively after 25 weeks, and thereafter reflected the degree of depletion below the minimum level commensurate with normal function. At 41 weeks, aspiration biopsy samples of the livers of the deficient and control animals contained respectively 0·08 and 1·12 μgm. vitamin B_{12}/gm. wet weight. The rate of depletion indicated by the vitamin B_{12} concentration in the blood was as follows:

Sheep No.	m.μgm. vitamin B_{12}/ml. blood at week number			
	26	32	41	56
A7-507 (deficient)	0·17	0·16	0·032	—
A7-566 (cobalt supplemented)	1·9	2·2	2·4	3·4

Sheep No. A7-507 was thus in an advanced stage of vitamin B_{12}-deficiency when it was slaughtered at 46 weeks to obtain its liver for the *in vitro* experiments reported in Fig. 5.

isomerase in the liver, as indicated by microbiological assays of the vitamin B_{12} content.

Some measure of further change occurs in both instances. When a $^{13}CO_2$-enriched atmosphere is employed, traces of fumarate and malate, both labelled with carbon-14, may be detected in the reaction mixtures.

As the total carbon dioxide bound in the combined methyl malonate and succinate fractions was observed in all instances to be closely similar, irrespective of additional co-isomerase—in the experiment reported in Fig. 5 they were, perchance, identical—it is clear that the potential efficiency of the propionyl carboxylating enzymes, described by Flavin and Ochoa[1], is not impaired in vitamin B_{12} deficiency.

The virtual stasis in the capacity of the intact mitochondria from the livers of vitamin B_{12}-deficient sheep to catabolize propionate invites comment. In the absence of a necessary quota of methyl malonyl co-isomerase, it is conceivable that conversion of propionate to succinate by an orientated array of enzymes within the mitochondria is stemmed back by local high concentrations of methyl malonyl coenzyme *A* at the reaction site. Such local accumulations of this intermediate as could greatly impede clearance through the propionate → methyl malonate → succinate channel would be relatively minute in terms of concentration within the reaction mixture as a whole. Certainly, sensitive chromatography failed to demonstrate the presence of either methyl malonate or its coenzyme *A* thioester in these reaction mixtures.

The methyl malonyl co-isomerase, employed in the first experiments (Fig. 5), was isolated from sheep's liver by a procedure similar to that employed by Barker and his colleagues[2] for the isolation of the adenyl cobamide coenzyme from *Clostridium tetanomorphum*.

As it was feasible for us to separate only a small quantity of the active vitamin B_{12} component from the liver, the precursor vitamin B_{12} was tagged with cobalt-58 to facilitate its identification during fractionation. On each of four consecutive days, 25 μgm. of vitamin B_{12}, containing 2·92 μc. cobalt-58 vitamin B_{12} was injected subcutaneously into a vitamin B_{12}-deficient sheep. The animal was slaughtered 24 hr. after the last injection. Its liver, which contained 14·3 per cent of the total radioactivity administered as cobalt-58 vitamin B_{12}, was finely ground, together with sufficient normal sheep's liver to yield 2 kgm. of minced tissue. After extraction with 80 per cent ethanol and preliminary purification, the major radioactive peak of the *p*H 6·4 eluate of the material adsorbed on a 'Dowex-50' *p*H 3·0 column was collected, extracted with phenol and re-extracted finally into 18·6 ml. of water. This solution contained 30 per cent of the cobalt-58 present in the original liver-mash. Addition of potassium cyanide to a sample of it changed the absorption spectrum to a curve, with maxima at 350, 367 and 581 mμ, that is characteristic of the cobamides. Microbiological assay (*Lactobacillus leichmannii*) of this sample indicated a concentration of $7·9 \times 10^{-8}$ molar co-isomerase in the final solution.

The relationship between the concentration of the coenzyme and the rate of conversion of propionate to succinate by homogenates of the livers of vitamin B_{12}-deficient sheep under the conditions outlined in the legend to Fig. 5 agreed tolerably well with the requirements, *Km*., of the Michaelis-Menten equation[3]. This criterion was employed for the comparison of the sample separated from liver with the two samples of 5:6-dimethylbenziminazole cobamide coenzyme kindly presented by Dr. Barker and Dr. Perlman. In the experiments employed for this purpose the concentration of the former was assessed from its vitamin B_{12} content: the concentrations of the crystalline samples were determined spectrophotometrically[4]. The apparent *Km*. values of all three ranged closely about 9×10^{-9} *M*. Thus there is little doubt that the coenzyme reported in Fig. 5 was in fact identical with the crystalline preparations.

H. R. Marston
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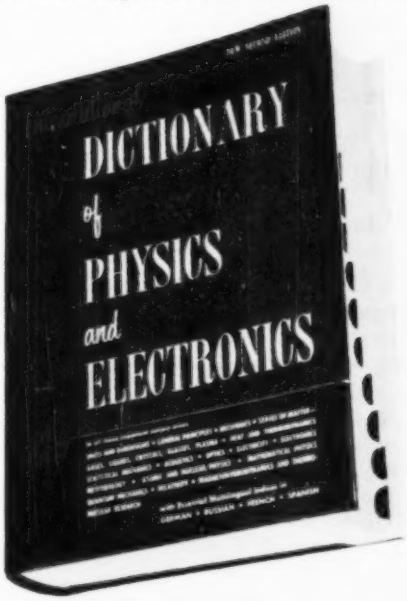

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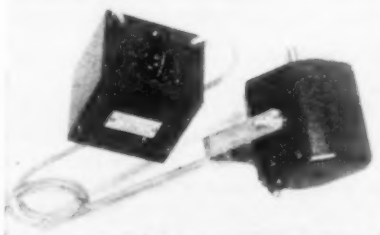

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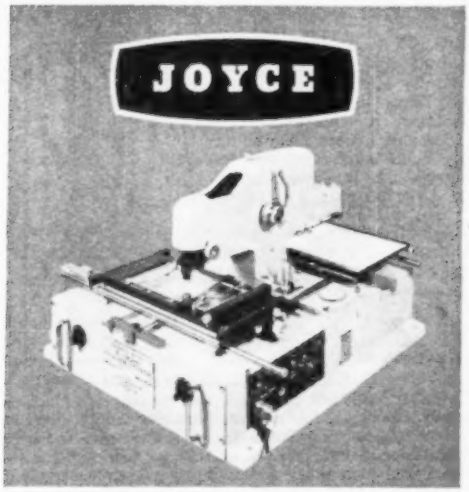

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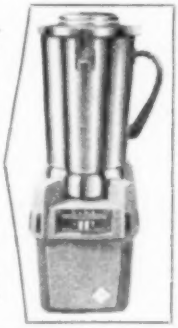

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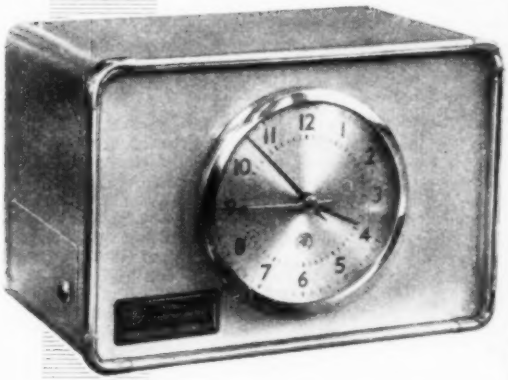

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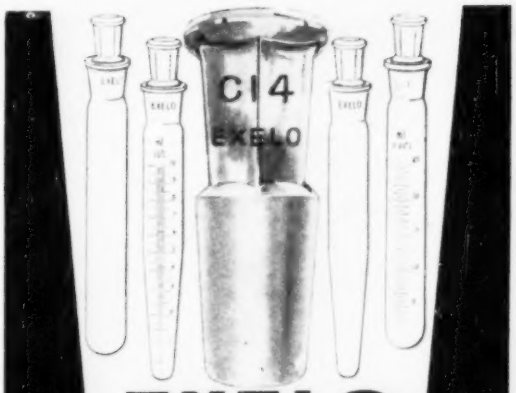

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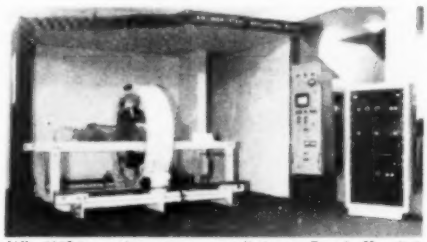

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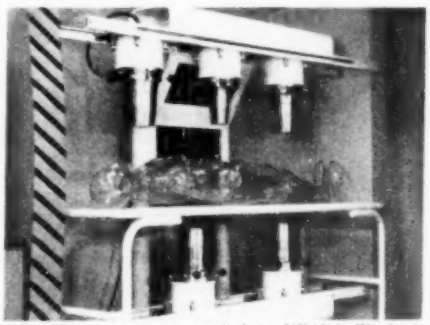

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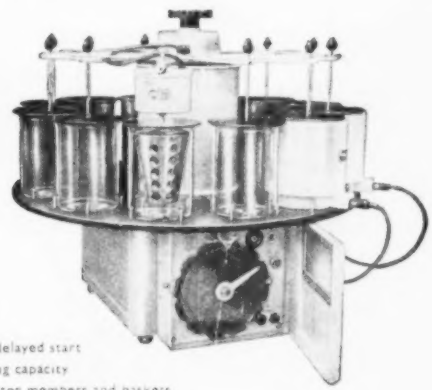

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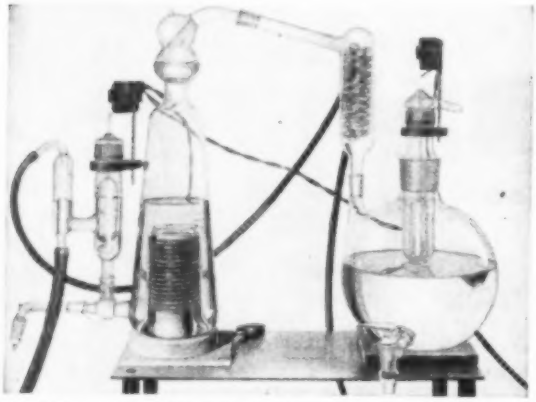

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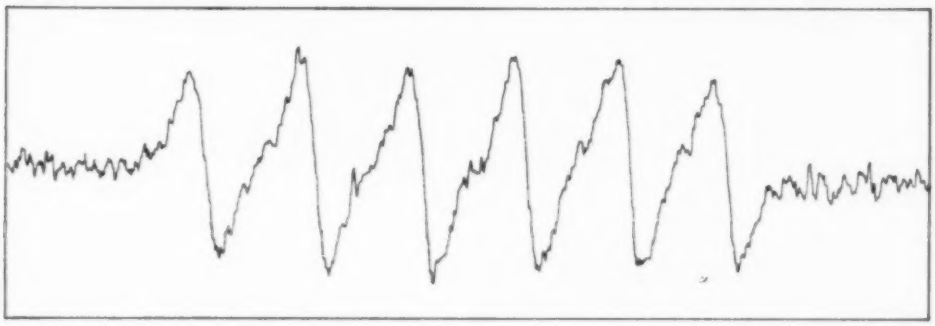

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Lack of Influence of Vitamin B_{12}-Deficiency on the Sheep's Capacity to metabolize Glutamate

Barker *et al.*[1] fixed attention on the essential function assumed by derivatives of vitamin B_{12} and its analogues in transfer reactions concerned with isomeric change by demonstrating that *Clostridium tetanomorphum* metabolizes L-glutamate via α-L-β-methylaspartate to mesaconate, and proving that the isomeric conversion of L-glutamate to α-L-β-methylaspartate is normally dependent on a coenzyme form of pseudo-vitamin B_{12} (adenyl cobamide).

In animal tissues L-glutamate is usually considered to be catabolized by simple oxidative deamination to α-ketoglutarate[2], with which it forms an equilibrium, thence via the Krebs cycle. An alternative pathway in which aspartate and oxaloacetate are involved has recently been suggested[3].

The sheep's capacity to deal with glutamate is unintluenced by vitamin B_{12} deficiency.

The procedure adopted in the experiment reported here is typical of the series in which comparative determinations were made on the same animal before and after correction of the imposed deficiency by injection of vitamin B_{12} (Fig. 7).

Glutamate in the blood plasma was estimated, after precipitation of the proteins[10] with picric acid and removal of the excess picric acid from the filtrate on a column of the chloride form of 'Dowex 2-X8', by separation[11] from other amino-acids on a column of the acetate form of 'De-Acidite *FF*' and estimation with ninhydrin.

As the peak of the concentration of glutamate in the blood stream immediately subsequent to the infusion of 3·5 m.mol. of glutamate/kgm. body-weight was somewhat above renal threshold, about 20 per cent of the glutamate injected was passed in the urine during the course of 3 hr. The findings, however, leave little doubt that, in sheep, vitamin B_{12} does not enter into any of the metabolic transactions involved in the catabolism of glutamic acid (Fig. 8). Under the conditions of the experiment the defect in the metabolism of propionate is clearly revealed (Fig. 9).

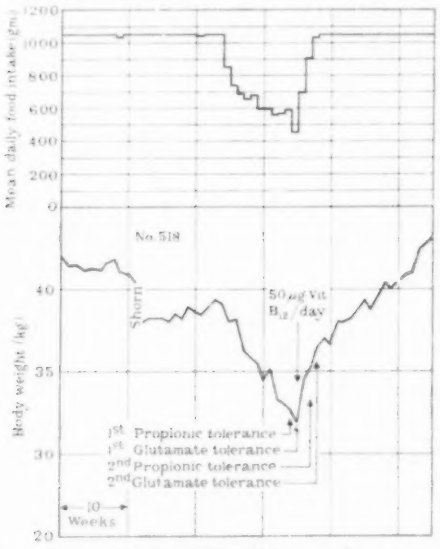

Fig. 7. Course of the vitamin B_{12}-deficiency syndrome in Sheep No. 518

The procedure was typical of the series in which comparative metabolic efficiencies were determined in one animal. The degree of deficiency in No. 518, as reflected by its food intake, was not so serious as that of the untreated member of the pair in Fig. 1. The impairment of its propionate metabolism was thus less serious. (cf. Figs. 4 and 9)

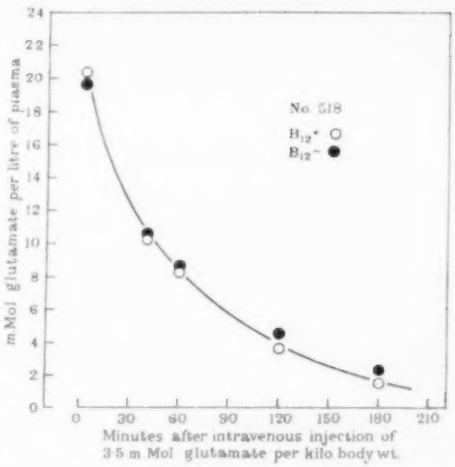
m.Mol glutamate per litre of plasma
No. 518
B12+
B12-
Minutes after intravenous injection of 3·5 m.Mol glutamate per kilo body wt.

Fig. 8. Lack of effect of vitamin B_{12}-deficiency on the metabolism of glutamate

The concentrations of glutamic acid prior to injection were about 0·07 m.mol. per litre of plasma

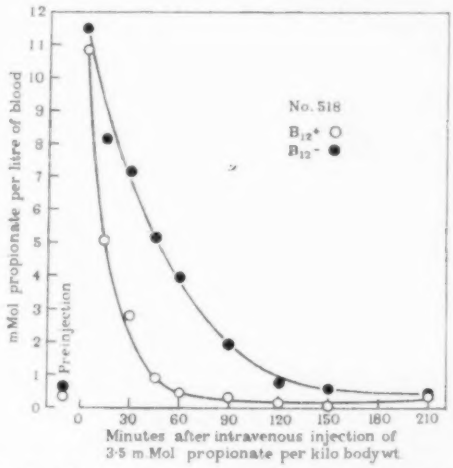

Fig. 9. Effect of vitamin B_{12}-deficiency on the metabolism of propionate

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LETTERS TO THE EDITORS

HISTORY OF SCIENCE

Observation in the Year 1648 of Diffraction through a Lattice

In the first half of the seventeenth century there worked in Bohemia the naturalist, physician and philosopher, Ioannes Marcus Marci (1595–1667), professor of the Faculty of Medicine in the University of Prague. It is known that Marci published in 1639 his book "De proportione motus", wherein he defined the laws governing impact of spherical bodies.

Besides other works in the field of physics, mathematics, medicine and philosophy he also wrote a book *Thaumantias. Liber de arcu coelesti deque colorum apparentium natura, ortu et causis* in the year 1648, in which he dealt with the origin and qualities of rainbow and "fictitious" (spectral) colours.

The book is remarkable in that Marci described in it certain observations of phenomena in the field of physical optics, about which published reports appeared only much later. Marci described, but without correct knowledge of the causes of these phenomena, the colour of thin plates (p. 241) and diffraction (pp. 103, 111, 119, 138, 178). In these chapters Marci did not speak only of diffraction on a wire, edge and aperture, but spoke directly (p. 119) about the system of apertures, which he called the lattice ("reticulum"):

"If you put the lattice before a light source, you will see as many rainbows, as there are apertures", as translated from the original, namely, " . . . si reticulum opponas luminoso, nam totidem irides, quot foramina, videbis".

Marci spoke of the lattice also on p. 138. "Itaque cancelli reticulatim intersecti ad singula foramina suas irides habent proprias."

Furthermore, Marci also mentioned the observation of spectral colours on the apertures formed by meshes of wires or threads (p. 103):

"Or plate with the apertures in the form of grating or twisted wires (threads) develops as many rainbows as one has apertures or slits through which light penetrates. Individual glasses in window frames behave in a similar way. But if we put a net in front of one of them, again there appears as many rainbows as there are apertures", from the original, namely: "Quin lamella in modum reticuli pertusa, aut filamenta convoluta totidem irides procreant, quot foramina seu rimae luci perviae. Ita quoque orbiculi vitrei fenestrarum singuli suas irides habent. Atque si illorum uni reticulum obtendas, rursum totidem irides quot foramina procreabis".

These quotations from Marci's book "Thaumantias" allow us to date the first known report about diffraction through lattices to the year 1648, that is, to the year of issue of his book.

I thank Dr. Ladislav Křivský, scientific worker of the Czechoslovak Academy of Sciences, for his support.

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PHYSICS

Concentration of Atmospheric Radon and Wind Direction

It is usually assumed that atmospheric radon comes from the Earth's crust by a slow diffusion process[1,2]. We may expect that radon concentration will change with wind direction at the time of sampling, according to the geographical and geological configuration near the sampling station.

The situation of our laboratory, in Lisbon, near the sea, is therefore excellent to test any probable relationship between radon concentration and wind directions since only half the possible wind directions are continental ones, therefore corresponding probably to higher radon concentrations. In order to study any correlation, the concentration of radon in air has been measured, by a method described in ref. 3. The wind directions have been recorded as is usually done in meteorology (sixteen directions).

Table 1 shows the number of observations for each direction and radon concentration data grouped in ranges of 5×10^{-14} c./l. In Fig. 1 the mean value of radon concentration corresponding to each wind direction is plotted in polar co-ordinates centred in Lisbon, over a chart of Portugal. From this we can conclude:

(1) Continental winds are generally related to higher concentration-levels of atmospheric radon.

(2) Sharp maxima are observed in those directions passing over the regions where uranium ores are present in great quantities.

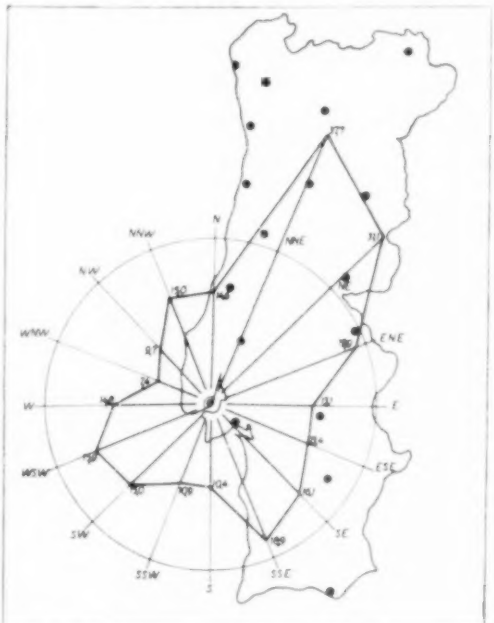

Fig. 1

Table 1

	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	Total	cm.
N.	37	34	31	19	16	12	6	6	2	3	0	—	—	1	1	2	1	205	14·6
N.N.E.	3	8	9	5	3	3	2	3	7	2	4	3	1	—	2	—	4	54	37·7
N.E.	4	8	10	—	15	11	6	8	9	5	3	3	1	1	4	1	1	100	31·1
E.N.E.	1	5	6	3	5	1	—	—	1	1	—	2	—	—	—	—	—	27	19·9
E.	—	3	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	5	13·1
E.S.E.	—	1	1	2	1	—	—	—	—	—	—	—	—	—	—	—	—	5	13·4
S.E.	—	4	1	1	—	1	—	—	1	—	—	—	—	—	—	—	—	9	16·1
S.S.E.	—	—	—	3	2	—	—	—	—	—	—	—	—	—	—	—	—	5	18·9
S.	9	5	3	1	—	1	—	—	1	—	—	—	—	—	—	—	—	23	10·4
S.S.W.	15	16	10	3	2	1	2	—	—	—	—	2	—	—	1	—	—	53	10·9
S.W.	17	18	15	4	5	1	1	1	1	—	1	—	—	—	1	—	2	57	15·0
W.S.W.	27	24	11	6	3	4	2	1	3	1	1	1	1	1	—	1	1	94	15·9
W.	3	4	—	3	1	—	—	—	—	—	—	—	—	—	—	1	—	11	14·8
W.N.W.	9	3	—	1	1	—	1	—	—	—	—	—	—	—	—	—	—	21	7·4
N.W.	6	8	4	4	1	1	—	—	—	—	—	—	—	—	—	—	—	24	9·7
N.N.W.	33	20	28	12	9	9	3	1	2	3	1	2	1	1	—	—	—	135	15·0

Variations of radon concentration with wind direction have already been observed by Tanaevsky and Vassy[4], and Stierstadt[5]. In the present work we can, furthermore, correlate higher concentration-levels with those directions corrsponding to well-established situations of uranium ores.

The above conclusions should be kept in mind when we intend to use the variation of radon concentration in the atmosphere as a sign of temperature inversion, particularly in those places where the geographical situation may explain radon variations by any other reason, as for example in Lisbon, as we found.

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Electrical Conductivity and Thermoelectric Power of Calcium Oxide

During recent years a number of experimental investigations of the physics of the oxide-coated cathode have taken the form of determinations of the thermionic and electrical properties of the individual alkaline earth oxides. The work reported in this communication represents part of a programme of research on calcium oxide, a component of some commercial mixed oxide coatings which has received but little attention.

The electrical conductivity of samples of calcium oxide has been determined in an experimental arrangement in which the oxide, in a layer about 100μ thick, is contained between two nickel cathode buttons. Each button is provided with an independent heater and the temperature of the nickel base may be determined by the use of a tungsten–nickel thermocouple attached to it. The assembly is attached to a glass pinch and is contained within a glass envelope, attached to a vacuum system. The oxide sample is prepared by the pyrolysis of a carbonate suspension, and after the usual techniques of breakdown, outgassing and activation (by applying 4 V. d.c. between the nickel buttons at 1,100° K., with frequent reversals of polarity, for a period of up to 12 hr.) the tube is sealed off from the system and an active barium getter is fired.

Measurements of the electrical conductivity of the calcium oxide sample as a function of temperature are made by setting both nickel buttons to the desired temperature T and determining the conductivity current when potentials of up to 500 mV. are applied between the buttons. For small applied voltages, the current-voltage characteristics are linear, the gradient providing a measure of the conductivity σ of the sample. Graphs of $\log \sigma$ versus $1/T$ show the characteristic form associated with conduction in the porous sample: a typical curve is shown in Fig. 1. Following the interpretation of Loosjes and Vink[1] the linear portion at lower temperatures (up to about 800° K. in this case) is associated with semiconduction through or over the surface of the crystallites making up the sample; the gradient of the low-temperature portion corresponds to an activation energy of 0·72 eV. for this process, for the particular state of sample activation under investigation. A second linear portion occurring between about 800° K. and 1,000° K. is associated with the thermionic emission of electrons within the pores of the sample. The activation energy of this high-temperature process, corrected for the parallel low-temperature mechanism, is 1·27 eV. Deviation from linearity at higher temperatures may be due to the current density in the pores becoming large enough for space-charge effects to be important. The most active samples gave an average low-temperature activation energy of about 0·7 eV., and an average corrected high-temperature activation energy of about 1·2 eV. Measurements in the low-temperature region were often hampered by the effects of thermal

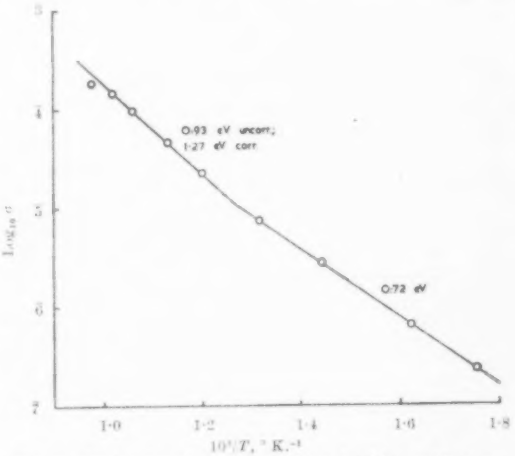

Fig. 1. Electrical conductivity of activated calcium oxide as a function of temperature. The conductivity σ is expressed in ohm^{-1} cm.$^{-1}$

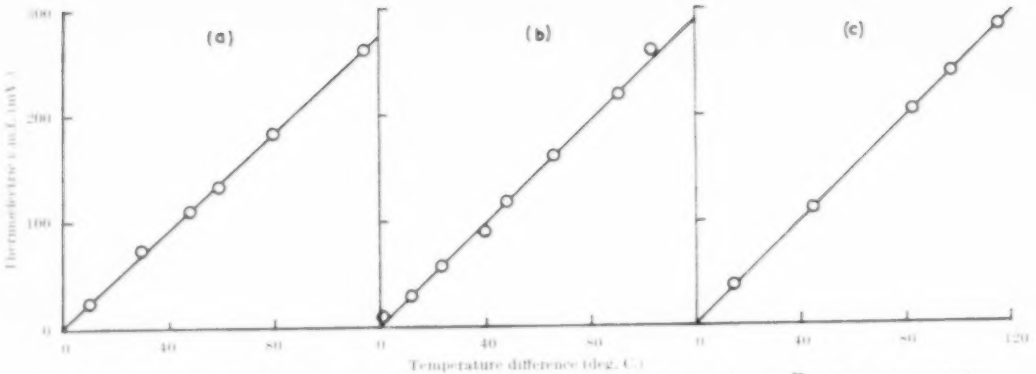

Fig. 2. Thermoelectric e.m.f. versus temperature difference characteristics for calcium oxide. *a*, $\bar{T}$ = 896° K., thermoelectric power = 2·30 mV. °C.$^{-1}$; *b*, $\bar{T}$ = 823° K., thermoelectric power = 2·41 mV. °C.$^{-1}$; *c*, $\bar{T}$ = 749° K., thermoelectric power = 2·43 mV. °C.$^{-1}$

expansion in the sandwich system; slight changes in the area of contact of the crystallites would be expected to have a considerable effect on the component of the conduction current due to true semiconduction, but only a small effect on the thermionic emission component. The average activation energies are in reasonable agreement with the values quoted by Hopkins and Vick[2] (0·8 and 1·3 eV.) from measurements of the electrical conductivity of calcium oxide with a different sample geometry.

The experimental arrangement adopted allows, in addition, the measurement of the thermoelectric power of the oxide. If the buttons are maintained at different temperatures, a thermoelectric e.m.f. is set up between the faces of the sample which may be measured with a vibrating condenser electrometer of effectively infinite impedance. It is convenient to increase the temperature of one button and decrease that of the other so that the mean temperature $\bar{T}$ is approximately constant. It is found that the thermoelectric e.m.f. thus produced is approximately proportional to the temperature difference between the buttons (at least for temperature differences of up to about 120° C.), and the gradient of the thermoelectric e.m.f. versus temperature-difference characteristic defines the thermoelectric power of the specimen at the mean temperature $\bar{T}$. A typical series of characteristics for a particular sample of calcium oxide is given in Fig. 2. Although in many cases the thermoelectric power shows a tendency to increase with decreasing mean temperature, the experimental error involved in individual measurements of thermoelectric power is too great to allow an accurate determination of the temperature variation. Metson and Holmes[3], in a study of the thermoelectric power of the mixed oxide (BaSr)O, suggest that in the high-temperature range the thermoelectric power is in fact constant, the apparent temperature variation being due to experimental inaccuracies. On this assumption an average thermoelectric power for calcium oxide in the temperature-range 700–1,200° K. has been calculated from determinations on a number of oxide samples: the value obtained is 2·4 ± 0·2 mV. deg. C.$^{-1}$.

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Modification of Spectrophotofluorometer for Scanning Paper Strips

The spectrophotofluorometer is a potent addition to biochemical investigations[1]. The apparatus, at present available from commercial sources, is designed for analysis of liquid solutions. By modifications of the basic design of the spectrophotofluorometer, as indicated in Fig. 1, the spectrophotofluorometric analysis can be applied conveniently to paper strips.

A mirror (*A*) deflects the pathway of the activating light which focuses at the point (*B*) on the paper strip which is mounted on the drum (*C*).

The paper strip used is obtained by high-potential paper electrophoresis. An example of such a result is shown in Fig. 2, for separation of three indolic compounds. The paper strips, resulting from the high-potential electrophoretic process, were dried and mounted on the drum (*C*) of the instrument by means of black insulation tape. There are, on the surface of the drum, six guides to accommodate six strips of paper 23 × 3·4 in. on six levels. By means of the lock mechanism of the shaft (*D*) supporting the drum, each of the six levels corresponding to the six strips can be brought into the focus of scanning without opening the lid of the drum chamber. The drum is set into rotation by a motor (*E*) at any level synchronously with the recorder.

Although the instrument can be applied to paper strips obtained by one-dimensional paper chromatography, the sharpness of separation obtained by high-potential electrophoresis makes the latter better suited to this technique.

The data so far available with reference to fluorescence of compounds of biological interest refer mainly to fluorescence of solutions. These data cannot be simply extrapolated to the fluorescence phenomena under discussion, because the compounds separated on the paper under scanning are in a solid state.

In the experiment such as Fig. 2, the best settings for fluorescence under these conditions, for most of the indolic compounds tested, are 2900 Å. for the activation wave-length, and 3400 Å. for the fluorescence. These data are not very different from those given for the fluorescence in water solution for tryptophan (*p*H 11), serotonin (*p*H 2) and tryptamine (*p*H 7) (ref. 2). It is expected, however, that data reported by other investigators, with regard to fluorescence of compounds of biological interest, in

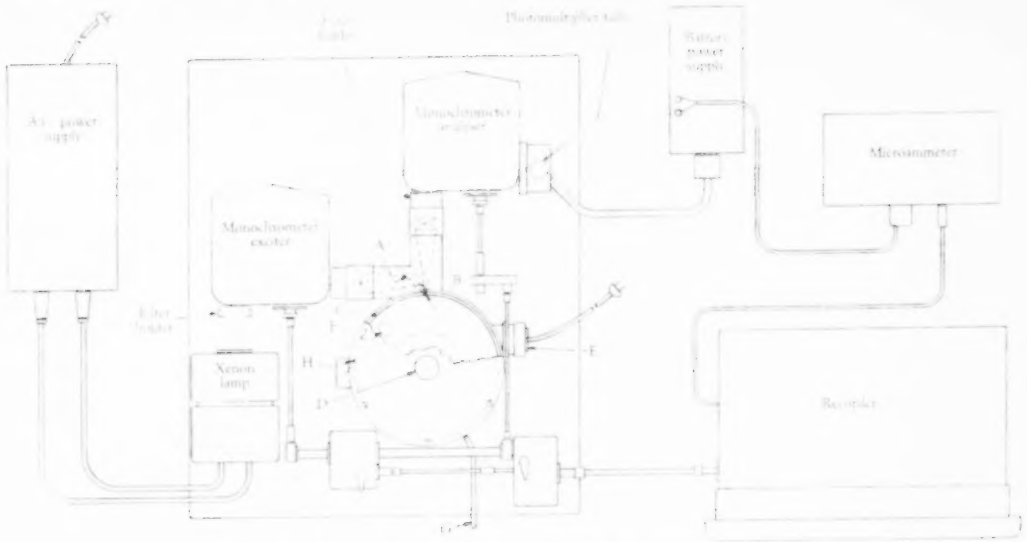

Fig. 1. Modification of spectrophotofluorometer for the spectrofluoro-phoretogram

solutions at various pH are not necessarily in agreement with the fluorescent data under discussion. Similarly, other salient features of fluorescence of compounds in solution such as quenching by chemical means or change induced by freezing would have to be retested. The drum in the basic part of this instrumentation serves not only for the purpose of scanning with least danger of contamination of the sample, but also to provide cooling of the paper, by introducing liquid nitrogen through one of the inlets (F), while the system is flushed with dried nitrogen-gas, introduced through the inlet (G) for prevention of fogging. The temperature of the paper surface is defined by the reading of the thermocouple making switching contact on the paper at point (H).

In view of the above-mentioned combination of high-potential paper electrophoresis and spectrophotofluorescent scanning technique, and because the fluorescence is of compounds in the solid state rather than in solution, the term spectrofluoro-phoretogram (SFPG) is proposed to specify the data (as in Fig. 2) obtained by scanning the paper electrophoretic pattern by means of this apparatus.

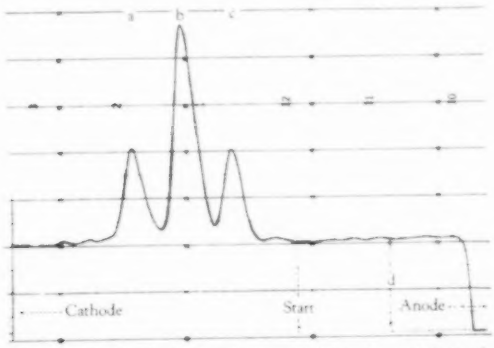

Fig. 2. Spectrofluoro-phoretogram (SFPG) of separation of L-tryptophan, serotonin and tryptamine. *a*, Tryptamine (equivalent to 4γ); *b*, serotonin (equivalent to 3γ); *c*, L-tryptophan (equivalent to 2γ); *d*, 'background fluorescence' of the paper strip. Electrophoresis, paper, Schleicher and Schuell 2043 *A*; electrolyte solution, 0·05 *N* formic acid, 0·2 *N* acetic acid; voltage, 10 kV.; time, 8 min. Activating light, 2900 Å. (filter, Corning 9863); fluorescent light, 3400 Å. (filter, *I G* 10); temperature, ambient

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Axial Migration of Particles in Poiseuille Flow

IT was reported recently[1] that rigid spheres concentrate into a thin annular region when an initially uniform suspension undergoes laminar flow through a straight circular tube at particle Reynolds numbers between 10^{-3} and 6×10^{-2}; while not completely explained, the phenomenon was attributed to the Magnus inertial effect.

We have conducted similar experiments with single spheres, rods and disks at much lower Reynolds numbers ($< 10^{-4}$), and have found that migration of the particles away from the walls occurs only when the particles are deformed in the shear field. The rotation of rigid particles in spherical elliptical orbits and the deformation of fluid drops into prolate spheroids agreed well with the corresponding theories of Jeffery[2] and Taylor[3] for Couette flow.

The experiments were rigorously controlled to prevent sedimentation of the particles and to exclude convection currents. The suspending fluid flowed through a vertical precision-bore tube of radius $R =$

0·4 cm. and isolated particles were observed (without optical distortion) in the median plane of the tube normal to the viewing axis of an electrically driven travelling microscope. Reproducible flow was produced by an automatic infusion-withdrawal pump which moved the liquid back and forth through the tube.

Continuous experiments were conducted over periods up to 24 hr. at flow-rates Q varying from 3·5 to 7·0 × 10^{-2} cm.^{3} sec.$^{-1}$ using rigid polystyrene spheres (radius $b = 0·01$ cm.) and disks ($b = 0·04$ cm., particle axis ratio $r_p = 0·20$) and 'Dacron' rods (length $l = 0·04$ cm., $r_p = 30$). Even when the particle centres were within $2b$ or l of the wall, no measurable migration occurred after the particles travelled over distances between 350 and 3,500 cm.

In striking contrast, liquid drops and tiny threads undergoing shear-deformation[4,5] migrated towards the tube axis. With liquid drops the rate of migration $-(dr/dt)$ increased with increasing b, Q and radial distance r from the tube axis.

An analysis of the forces operating on a fluid sphere has shown that when the velocity gradient G in the suspending fluid varies from one side of a particle to the other, there is a net force driving the particle in the direction of diminishing G. In Poiseuille flow, the gradient varies linearly with radial distance r from the tube axis:

$$G = -kr \qquad (1)$$

where

$$k = 4Q/\pi R^4 \qquad (2)$$

The net radial force on a fluid drop is calculated with the aid of Taylor's theory[6] for small deformations to be:

$$F_{rr} = \pi\eta_2 b^3 r_2 D f_1(p) \qquad (3a)$$

where D is the deformation given by[6]:

$$D = \frac{Gb\eta_2(19p + 16)}{\gamma(16p + 16)} \qquad (3b)$$

p being the viscosity ratio (suspended phase)/(suspending phase) = η_1/η_2, and γ the interfacial tension. Assuming that the drop is propelled radially with Stokes velocity (corrected for internal circulation[7]) the migration velocity becomes:

$$-dr/dt = \frac{\pi\eta_2}{48\gamma} f_2(p) k^2 b^3 r \qquad (4a)$$

where

$$f_2(p) = \frac{(19p + 16)(8p^2 + 39p + 30)}{3(16p + 16)(3p + 2)} \qquad (4b)$$

Integration of equation (4) yields:

$$\log_e\left(\frac{r_0}{r}\right) = \frac{\pi\eta_2}{48\gamma} f_2(p) k^2 b^3 t \qquad (5)$$

r_0 being the radial distance at time $t = 0$.

It should be noted that this theory predicts that no migration occurs with rigid spheres ($D = 0$) in Poiseuille flow and with deformable spheres in Couette flow ($k = 0$), in accord with experiment.

The variation of r with t for water drops ($b = 0·02$ to 0·04 cm.) in 50 poise silicone oil was measured in a range of values of k (1·8–7·1 cm.$^{-1}$ sec.$^{-1}$). When plotted according to equation (5) the experimental points fell on a single curve initially linear and then curving as the particle approached the tube axis. The mean measured/calculated slope of the linear portion was 0·3. In view of the neglect of wall proximity on the Stokes velocity and other approximations, the agreement with theory is good.

The phenomena reported here provide one possible mechanism for the development of a particle-free peripheral zone adjacent to the wall observed in the laminar flow of suspensions of deformable wood-pulp fibres[8] *in vitro* and of deformable red blood cells *in vivo*[9,10]. At the finite concentrations prevailing in these systems, however, axial migration of the peripheral particles may be expected to stop when the radial force F_{rr} is resisted by the elastic compression of the central core of particles, as actually observed in fibre suspensions.

Details of the theory and experiments will be published elsewhere.

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GEOPHYSICS

Dispersions of Multiple-Stroke Whistlers

The dispersions of 233 multiple-stroke short whistlers recorded during the International Geophysical Year at Durban (geomagnetic co-ordinates 31° 34′ S., 93° 04′ E.) have been measured from sonagrams. Dispersions were determined graphically using the Eckersley[1] dispersion law $t^2 = D^2/f$, where t is the time-interval between the lightning flash producing the whistler and the arrival at the observer of the component of radiated energy of frequency f; D is a measure of the dispersion of the whistler. The linear relationship between $f^{-1/2}$ and t was plotted for each whistler, the dispersion being obtained from the slope.

Those whistlers with two components only were classified into three groups in which the intensity of the second component was (*a*) significantly greater than, (*b*) approximately equal to, and (*c*) significantly less than, that of the first component. In each case the mean value of the ratio D_2/D_1 of the dispersion of the second component to that of the first was calculated. The results are shown in Table 1.

Table 1. Dispersion Ratios of Components for Whistlers with Two Components Only

Intensity of second component	No. of records	No. with $D_2/D_1 > 1$	No. with $D_2/D_1 < 1$	Mean value of D_2/D_1
(*a*) Greater than first	43	39	4	1·10 ± 0·02
(*b*) Approximately equal to first	53	36	17	1·04 ± 0·01
(*c*) Less than first	34	24	10	1·07 ± 0·02
All groups	130	99	31	1·064 ± 0·009

Calculation of the 95 per cent confidence limits for the mean value of the dispersion ratio for all groups indicated that the probability of this ratio being less than or equal to unity is less than 1 in 10,000.

For those multiple-whistlers with three or more components the ratios of the dispersions of successive components are given in Table 2.

Table 2. Dispersion Ratios of Successive Components for Whistlers with Three or More Components

Dispersion ratio	D_2/D_1	D_3/D_2	D_4/D_3	D_5/D_4	D_6/D_5	D_7/D_6
Mean value of ratio	1·04 ± 0·01	1·07 ± 0·01	1·05 ± 0·02	1·09 ± 0·04	1·05	1·07
No. of records	103	103	39	15	4	1

Although the number of records available for the values given in the last three columns of Table 2 is too small for these particular figures to be reliable, the overall analysis indicates a 4–6 per cent increase in the dispersion of successive components of a multiple-stroke short whistler.

It is interesting to note that this result may indicate support for the current-jet hypothesis of whistler generation proposed by Hoffman[2]. If a stream of energetic electrons passes upwards through the top of the thundercloud during each interval of time between successive strokes to ground, an accumulative process of enhancement of electron density in the whistler path may be expected, with a consequent increase in the dispersion of successive whistler components. Furthermore, if such a process were responsible for the enhancement of energy in successive whistler components, it would be expected that for those records in which the second component is the more intense the dispersion ratio would be greater than for those records in which the second component is less intense. That this is the case can be seen from Table 1. In group (*a*) the mean value of the ratio is 1·10 ± 0·02 with 90 per cent of the records giving $D_2/D_1 > 1$, while in group (*c*) a lower mean value of 1·07 ± 0·02 is obtained and only 70 per cent of the records give $D_2/D_1 > 1$.

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Palæomagnetism and the Ancient Radii of the Earth

Cox and Doell[1], applying an earlier idea of mine[2], have determined a probable value of the Permian palæo-radius of the Earth. That communication was commented upon by S. W. Carey[3]. In all probability, Carey's contention that the distance of the sampling localities has since increased due to tectonical events is correct. However, to estimate the amount of the increase in distance as suggested by Carey means substituting one hypothesis by another, since Carey's theory is itself a hypothesis which awaits detailed proof and which will perhaps be found invalid in its present formulation. Since the application of palæomagnetic measurements to the determination of palæo-radii is just a way of proving the expansion of the Earth without auxiliary assumptions, the introduction of such assumptions certainly detracts from the value of the method as a proof.

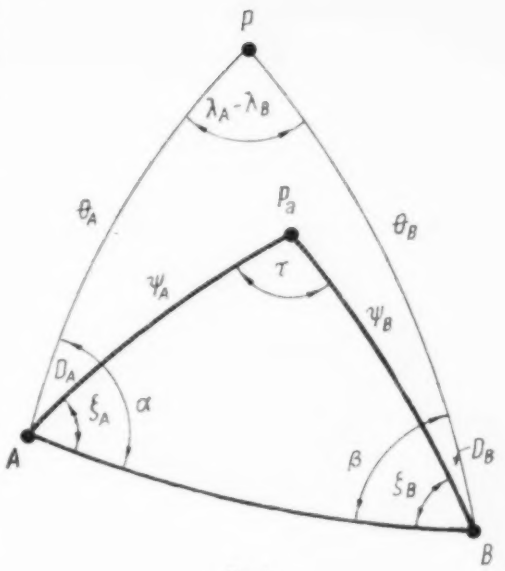

Fig. 1

Instead of the procedure suggested by Carey, I should like to propose a further refinement of the method employed by Cox[1] and Doell as follows:

(1) In a given age, the radius was practically the same for the whole Earth: consequently, it would be possible to treat together the data concerning separate stable blocks in a given period, diminishing thereby the statistical error.

(2) Plotting the data for radii for the individual periods against time, and applying a least-squares adjustment by assuming a linear variation with time, it would become possible to use almost all palæomagnetic data in determining the trend and rate of increase of radius. This would further decrease the statistical error.

Otherwise, I am convinced that the increase of radius can be considered linear and steady to a good approximation for at least the past 3×10^9 years and that the rate of increase is less than 1 mm. a year. In my opinion Carey's value is exaggerated.

(3) Undoubtedly, the method of determining palæo-radii is subject to the fewest possible errors if it is applied to sampling localities along the same palæo-meridian, but a very simple generalization permits the utilization of sampling localities not on the same meridian, and thus covers the bulk of the data. The palæomagnetic measurements on a given stable block and for a given geological period yield the inclinations I_A and I_B and declination D_A and D_B for two localities A and B. The distance $AB = d$ is also known for the present. The ancient pole position P_a and the points A and B form the apices of an ancient spherical triangle; the sides $AP_a = \psi_A$ and $BP_a = \psi_B$ are known ($\cot g\ \psi_A = \frac{1}{2} \tan I_A$; $\cot g\ \psi_B = \frac{1}{2} \tan I_B$) and it is possible to calculate the angles situated at the apices A and B, ζ_A and ζ_B ($\zeta_A = \alpha - D_A$ and $\zeta_B = \beta - D_B$, where α is the angle subtended by the present meridian through A and the segment AB and β the angle subtended by the present

meridian through B and the segment AB). Now we have:

$$\sin\alpha : \sin(\lambda_A - \lambda_B) = \sin\vartheta_B : \sin\Delta$$

$$\sin\beta : \sin(\lambda_A - \lambda_B) = \sin\vartheta_A : \sin\Delta$$

$$\cos\Delta = \cos\vartheta_A\cos\vartheta_B + \sin\vartheta_A\sin\vartheta_B\cos(\lambda_A - \lambda_B)$$

where Δ is the present-day central angle subtended by the segment AB, ϑ_A and ϑ_B are the present colatitudes of the points A and B and λ_A and λ_B are the present longitudes.

If now the values of ζ_A, ζ_B, ζ_A, ζ_B and d are known, then from the relations:

$$\cos\zeta_A\cos\zeta_B + \sin\zeta_A\sin\zeta_B\cos\tau = \frac{b}{a} + \frac{1}{a}\cos\tau = \cos\Delta_a$$

$$\frac{\sin\zeta_A}{\sin\zeta_B}\sin\Delta_a = c_1\sin\Delta_a = \sin\tau$$

$$\frac{\sin\zeta_B}{\sin\zeta_A}\sin\Delta_a = c_2\sin\Delta_a = \sin\tau$$

we have:

$$\cos\tau = a\cos\Delta_a - b \quad \text{where } c = \sqrt{c_1 c_2}$$
$$\sin\tau = c\sin\Delta_a$$

Whence:

$$(a\cos\Delta_a - b)^2 + c^2\sin^2\Delta_a = 1$$

Thus we have the equation:

$$(a^2 - c^2)\cos^2\Delta_a - 2ab\cos\Delta_a + (b^2 - c^2 + 1) = 0$$

which determines Δ_a.

The value of the palæo-radius is:

$$R_a = \frac{d}{\Delta_a}$$

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GEOLOGY

Hafnian Zircons

Among quadrivalent trace elements, hafnium is a constant and inseparable associate of the more common zirconium. All zirconium and zirconium-bearing minerals contain appreciable amounts of hafnium; zircon ($ZrSiO_4$), one of the most common accessory constituents in rocks, particularly those of granitic composition, is the main carrier of this element.

The highest hafnium content, as recorded recently by Levinson and Borup[1], is 22–24 per cent HfO_2. This was observed in zircons intergrown with the rare mineral thortveitite, $Sc_2Si_2O_7$, from a granite pegmatite in the Iveland area of Norway.

In connexion with geochemical studies of pegmatites in Uganda, Southern Rhodesia, Mozambique and South-West Africa, hafnium has been determined by X-ray fluorescence in zircons from various pegmatites and, for comparison, in zircons from other environments. The hafnium contents thus found have varied from 1 per cent HfO_2 in a zircon from the Sukulu carbonatite in Uganda, to 31 per cent HfO_2 in a zircon from a lithium-bearing pegmatite near Karibib, in South-West Africa.

It has been observed that zircons high in hafnium occur in certain lithium-bearing pegmatites rich in tantalum and carrying a typical suite of minerals such as tantalite, manganotantalite, microlite, cassiterite, amblygonite, manganoapatite, rose-coloured beryl, topaz, etc., which represent a late phase of pegmatite crystallization.

Coherent pairs of elements, that normally occur together, may be enriched during successive stages of crystallization, and in some cases even separate to form independent minerals. Niobium and tantalum — the odd-numbered neighbour elements of zirconium and hafnium—are in many ways geochemically similar. Thus, on one hand, zirconium and niobium, and on the other hafnium and tantalum, are found to be enriched in the same geological environments. Whereas tantalum may separate from niobium to form independent minerals, hafnium only becomes enriched relative to zirconium. According to Rankama and Sahama[2], this may be explained partly by the abundance ratio of niobium-tantalum (11·4) being less than that for zirconium-hafnium (48·9).

Some lithium-bearing pegmatites constitute an example where almost complete separation of tantalum from niobium has occurred and tantalum minerals, for example, tantalite, manganotantalite, stibiotantalite, bismutotantalite, simpsonite, and a number of microlite varieties, have been formed[3]. If zirconium and hafnium are present in these pegmatites, the hafnium/zirconium ratio may well increase, and strongly enriched hafnian zircons, in which the weight percentage of hafnium may well exceed that of zirconium, are to be expected.

During the present work, two hafnian zircons have been examined in more detail, one from Mtoko in Southern Rhodesia, containing 21 per cent HfO_2, and the other from Karibib in South-West Africa, with 31 per cent HfO_2. In both cases the zircons are associated with the later tantalum-rich phase of mineralization. The Mtoko zircon forms small, mauve-coloured, independent crystals in the albitic zone of the pegmatite, and is associated with manganotantalite, microlite and bismutite. The zircon from Karibib occurs in larger reddish-brown masses, partly intergrown with minute manganotantalite crystals and set in a matrix of lithium-bearing mica, albite, quartz and kaolinized feldspar. Some crystals show dominant pyramid faces, with a suppressed prism.

The following properties have been determined for the hafnian zircons:

Mtoko zircon	sp.g. 4·91	R.I.ω = 1·920	ε = 1·972
Karibib zircon	sp.g. 5·2	R.I.ω = 1·92	ε = 1·97

Both zircons exhibit an intense golden-yellow fluorescence in ultra-violet light. The zircon from Karibib was found to be only weakly radioactive. A qualitative spectrographic analysis gave the following results:

Major: silicon, zirconium, hafnium.
Trace: beryllium, magnesium, aluminium, calcium, manganese, iron, tin.
Yttrium and rare-earths, if present, were below the limit of detection.

The zircon from Karibib was also chemically analysed, and the results obtained were as follows:

SiO_2	TiO_2	ZrO_2	HfO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	H_2O-	Total
29·20	0·0	70·20	trace	0·17	trace	0·0	0·0	0·23		99·80

The hafnium content as determined by X-ray fluorescence was found to be 31 per cent HfO_2.

X-ray powder data of the two zircons agree on the whole with the data given for zircon in the A.S.T.M. *X-ray Powder Data File*. As with many zircons, heating produces a more defined pattern for the Karibib zircon. Compared with low-hafnium zircon,

d-values of the unheated Karibib mineral are distinctly larger, while the heated zircon has rather smaller values. (The radius of the Zr^{4+} ion is 0·82 Å. and of Hf^{4+} ion 0·78 Å.). The difference in spacing is, however, too small to be of any practical value in distinguishing hafnian from normal zircons. An interesting feature, perhaps significant for hafnian zircons, was noticed in the relative position of the three lines representing the indices (532), (424) and (523, 620). In the hafnian zircon from Karibib the centre line of this triplet is clearly displaced toward the low-angle one; in the hafnian zircon from Mtoko it lies in a median position and in normal zircons is distinctly displaced towards the high-angle line.

Some recent data on the geochemistry of hafnium in granite pegmatites have been given by Vainshtein *et al.*[4]. Their views concerning hafnium enrichment in the late pegmatite crystallates are in good agreement with those presented in this communication.

We are indebted to Dr. R. S. Bradley and Dr. D. C. Munro of the School of Chemistry in this University for provision of facilities and for helpful advice in connexion with the X-ray fluorescence analysis, and to Miss J. M. Rooke for the spectrographic analysis of zircon.

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Salinity Response of Trace Element Concentration in *Crassostrea virginica*

In a search for ecologically significant variations in elemental concentrations in marine invertebrate skeletons, the concentrations of several trace elements in shells of *Crassostrea virginica* have been investigated. Samples of 71 specimens from 11 stations along the American coast between Massachusetts and Texas were analysed spectrographically for magnesium, strontium, manganese, sodium, boron, and copper. Correlations between elemental concentrations and the temperatures and salinities at which the oysters grew were assessed statistically.

At least five shells were sampled from each station. Wedge-shaped cross-sections were cut just behind the hinge region so that all periods of shell-growth, except the earliest, were represented, since reproducibility among shells from the same station was greatest in such samples. Ideally, average annual temperatures and salinities for periods of shell-growth should have been used, but precise data were not always available, so averages that include periods of several years not coinciding with shell-growth had to be used for some stations. Salinity data and mean concentrations ($\bar{X}$) and standard errors (*S.E.*) of several elements in all shells examined from each station are presented in Table 1.

Significant correlations were found between some elemental concentrations and salinity, although no correlations with temperature were apparent and neither strontium, magnesium, boron, nor copper was significantly related statistically to either temperature or salinity. For the results summarized here, a correlation coefficient (r) of 0·219 is significant at the 5 per cent confidence level. Significant correlations between elemental concentrations and salinity were found for manganese ($r = -0{\cdot}453$) and sodium ($r = +0{\cdot}356$). If individual strontium ($r = -0{\cdot}054$) and magnesium ($r = -0{\cdot}214$) concentrations are combined and then correlated with salinity, the coefficient is a significant $-0{\cdot}253$.

A multiple correlation of magnesium, magnesium plus strontium, manganese, and sodium with salinity has a coefficient of 0·533, higher than for any element alone. Taking into consideration the analytical accuracy and range of variation encountered in measured elemental concentrations among members of the same population, it appears that multiple regressions based on these four elements without transformation of raw data allow prediction, from concentrations in a single shell, of average salinity of waters in which shell-growth occurred, with a standard error of 5·3 parts per thousand. The accuracy of prediction may be enhanced by increasing the number of stations from which raw data are assembled and by increasing sample size. Furthermore, the multiple correlation coefficient is improved and standard error reduced when calculations are based on an assumption that the diadochic elemental correlations are logarithmic. Evidently the simple correlations are not linear. To certify their forms and assess fully their significance requires knowledge of elemental concentrations in the sea-water of shell-growth, which is not available.

Elements correlated negatively with salinity are those that are presumably diadochic with calcium in the calcite structure. Discrimination of *C. virginica* against these diadochic elements thus decreases in

Table 1. Mean Concentrations ($\bar{X}$) and Standard Errors among Individuals (*S.E.*) of Selected Trace Elements in Shells of *Crassostrea virginica*, together with Mean Annual Temperatures and Salinities of Waters in which the Oysters grew

Locality	No. of shells	Mean annual temp. °C.	Mean annual salinity ‰	Magnesium		Strontium		Manganese		Sodium	
				$\bar{X}$ p.p.m.	*S.E.*	$\bar{X}$ p.p.m.	*S.E.*	$\bar{X}$ p.p.m.	*S.E.*	$\bar{X}$ p.p.m.	*S.E.*
1	10	12·1	29·4	2062	386	1412	222	36·0	7·7	3225	1050
2	5	14·1	13·2	2186	365	1648	225	115·0	21·4	2064	245
3	16	16·1	19·2	2133	446	1472	140	61·3	10·7	2816	840
4	5	19·3	30·4	2070	340	1262	518	26·9	4·1	3170	555
5	5	20·1	?	2744	372	1142	158	75·9	44·5	2600	317
6	5	25·0	25·0	1972	429	1486	215	21·3	5·1	2570	630
7	5	21·0	30·0	1964	494	1572	23	44·6	23·3	3264	1616
8	5	21·5	13·7	2388	402	1184	57	54·2	12·3	2090	186
9	5	22·5	17·4	1964	431	1554	299	227·6	34·6	2150	317
10	5	21·9	13·5	2218	583	1425	36	67·7	54·4	2840	600
11	5	22·5	18·2	2158	459	1640	225	38·8	9·7	3190	520

Localities are: 1, West Chatham, Mass.; 2, Solomons, Md.; 3, Gloucester Point, Va.; 4, Beaufort, N.C.; 5, Sapelo Is., Ga.; 6, St. Petersburg, Fla.; 7, Alligator Harbor, Fla.; 8, St. George Is., Fla.; 9, Ocean Springs, Miss.; 10, Barataria Bay, La.; 11, Port Aransas, Tex.

waters of low salinity. Perhaps the lowered concentration of the preferred calcium ions stimulates acceptance of less desirable ions for shell construction. On the other hand, sodium is probably interstitial, and thus reflects salinity directly.

As characteristic differences in tolerance for trace element concentrations are found among even closely related taxa[1,2], the responses of other pelecypods are still conjectural. However, trace elements in fossil shells of *Crassostrea virginica* may be studied with the aim of establishing palæosalinities. Presumably, the accuracy of palæotemperature determinations by the oxygen isotope method may be enhanced by palæosalinity corrections.

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Geological Age of the Sandringham Sands

The Sandringham Sands, up to 100 ft. thick, form the basal member of the Cretaceous System in Norfolk and rest unconformably on the Jurassic (Kimmeridge Clay); their position in the Cretaceous time-sequence and their stratigraphical relations with other early Cretaceous deposits have hitherto remained in doubt owing to lack of palæontological data. Excavations near Abbey Station, West Dereham, Norfolk (Nat. Grid Ref. 53/65549969), made in connexion with the Fenland Flood Relief Scheme, have provided new sections in the Sandringham Sands from which officers of the Geological Survey and Dr. G. P. Larwood of the Sedgwick Museum, Cambridge, have collected a large suite of fossils indicative of a Berriasian (Infra-Valanginian) fauna new to Britain.

The fossils occur as clustered moulds in nodular masses of hard, grey-brown, glauconitic sandstone with carbonized plant debris, about 30 ft. above the base of the formation. Twenty-eight genera of Mollusca have been identified, mostly lamellibranchs, *Astarte* (*Neocrassina*), *Pholadomya*, *Panopea*, *Hartwellia*, *Isocyprina*, *Thracia*, *Myophorella* and *Isodonta* predominating. Cephalopods are represented by well-preserved examples of the ammonite *Hectoroceras*, described by Spath[1] in 1947 from S.W. Jameson Land, East Greenland, and by numerous hollow moulds of belemnite guards, including those of *Acroteuthis*. Some of the lamellibranch and belemnite species occur also in the Spilsby Sandstone (Berriasian) and superjacent Neocomian strata in Lincolnshire; others, such as the species of *Hartwellia*, *Isocyprina* and *Isodonta*, have their closest parallels in the Upper Jurassic (there is no previous record of *Isodonta* in the British Cretaceous, for example). Many of the shells were ravaged by the boring polyzoan *Gravesonia*, only recognized recently in the Cretaceous faunas of Britain[2].

The fossiliferous sandstone is followed within a few feet by the Lower Greensand (Aptian–Lower Albian), this determination being suggested by a rolled specimen of the ammonite *Deshayesites* found among the excavated material. This means that any equivalent of the Snettisham Clay (Barremian) of north Norfolk or the Valanginian–Hauterivian sequence of Lincolnshire is either absent or is present only in greatly attenuated form.

It is now clear that the Sandringham Sands are wholly or in part of Berriasian age and that in the West Dereham area the hiatus at their top is probably as great or greater than that at their base. It is not yet possible, however, to say precisely where this fossil band in the Sandringham Sands fits in with the fragmentary Berriasian successions in Lincolnshire and Yorkshire. In the Spilsby Sandstone there are three distinct ammonite-levels, all characterized by forms of *Subcraspedites*; the lowest, with the sub-genus *Paracraspedites*, is thought to be more or less contemporaneous with the basal Berriasian of East Greenland[3]. *Subcraspedites* is found both above and below *Hectoroceras* in East Greenland, so that the most likely position of the Norfolk *Hectoroceras* fauna is a horizon within or just above that of the Spilsby Sandstone.

Dr. Larwood is preparing a preliminary stratigraphical account of the section. The Geological Survey material referred to above is being further examined.

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AGRICULTURE

Evaluation of Effective Rainfall and Irrigation from Ground-water Measurements

A fraction of the total rainfall that reaches the ground water-table is called the effective rainfall[1]. Where there is irrigation, a fraction of the irrigation water also has been found to contribute to the rise of the water-table[2]. Effective values of rainfall and irrigation are usually determined using lysimeters[3]. The lysimeters, however, need correction for their size and the indications obtained from them are often high. A general figure found at Amsterdam dune water works, where there was no run-off, indicated that 61 per cent of a total rainfall of 659 mm. per annum was effective[1]. An actual determination of the rise in water-table over large areas has also been carried out by means of open well water measurements[4,5]. The effective values of rainfall and irrigation, however, do not seem to have been arrived at. An analysis of the changes in the ground-water level has therefore been taken up in this investigation, and the effective values of rainfall and irrigation were evaluated from the (fortnightly) measurements of the water-levels recorded for the past 20 yr. in thirteen wells randomly distributed over 565 acres of irrigated farm area of the Indian Agricultural Research Institute, New Delhi.

Fig. 1 gives the mean water-table levels on July 1 of each year, from 1940 to 1950, just before the beginning of the monsoons. This period is selected to be suitable as the water would reach a stable level just before the monsoons start[6]. The trends in the rise of

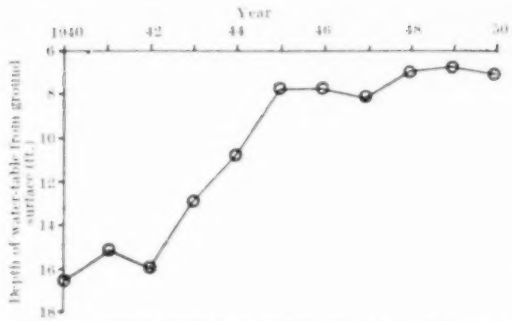

Fig. 1. Average water-table readings on July 1 each year

the water-table, however, remain the same irrespective of the period selected. As there is no conspicuous change in the level of the water-table after 1948, presentation of further data was not found necessary. The results indicate that during the years 1940–42 the increase in the ground-water level is small. During 1942–45, however, the rise in ground water is quite steep. This steep rise may be due to the fact that the drains then existing for the run-off provided on the farm area since 1936 were closed in 1942 with the view of conserving the rain water. In fact, the run-off became negligible in that period. The almost linear rise in the ground-water level permitted the evaluation of the effective values of rainfall and irrigation.

Table 1. Water-table Rise in Monsoon Period at the Farm Area of the Indian Agricultural Research Institute, July 1–December 31

Year	Rainfall R (in.)	Irrigation I (in.)	Well-water levels (ft.) on July 1	Well-water levels (ft.) on Dec. 31	Rise in ground-water level G (in.)
1942	21·24	15·97	15·97	12·80	38·04
1943	14·09	18·27	13·06	10·91	25·80
1944	22·82	22·86	10·93	6·53	52·80

Table 1 gives the rise in water-level in inches during the moonsoon period (July 1–Dec. 31), during which some of the rainfall or irrigation seeps down to the ground-water level. The other period, Jan. 1–June 30, is mostly a dry period at Delhi with scanty rainfall that just wets the top layers, but is not sufficient to saturate the top capillary zone and percolate down to the ground-water level.

The effective rainfall, aR, the effective irrigation bI, and the rise in the ground-water level, G, are related by the equation: $aR + bI = PG$, where R and I are the values of the total rainfall recorded and the total irrigation given during the monsoon season, and P the fractional pore space at the ground-water level. A solution of the three resulting equations arrived at by the principle of least squares is:

$$a = 1{\cdot}69\,P \text{ and } b = 0{\cdot}36\,P$$

The first 4·5 ft. depth of the soil is sandy loam with about 50 per cent porosity, while the layers below this are characterized by the presence of *Kankar* (calcium carbonate), the concretions becoming more and more calcareous downwards[7]. Such a compact soil usually has a porosity varying from 25 to 30 per cent. Using these values for P, the values of effective rainfall and effective irrigation turn out to be 42 per cent–51 per cent and 9 per cent–11 per cent, respectively. The values of the effective rainfall seem to agree fairly well with the observations made earlier in refs. 8–10 on Indian sandy loam soils. The effective percolation from rainfall seems to be much more than that from irrigation. This is a tribute to the irrigation management, since the design avoids excessive percolation.

In balancing the ground-water rise, the lateral movements of ground water, if any, have not been accounted for. The effective values are thus the minimum values possible. Work is in progress on the effect of lateral movement on the ground-water balance.

We thank Dr. B. P. Pal for his interest in the progress of this investigation.

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CHEMISTRY

Odour and Molecular Vibration

The low-frequency vibrations of organic molecules are largely unexplored, so that it is difficult to test directly the hypothesis that odours may be correlated with them[1]. An indirect test was therefore devised.

The low-frequency Raman lines of nitrobenzene and methyl salicylate are reported[2] to be:

Nitrobenzene	183			408 cm.$^{-1}$
Methyl salicylate	185	263	356	423 cm.$^{-1}$

If these values are correct and complete, then, on the above hypothesis, their odours should be basically similar but with the odour of methyl salicylate altered from almond-like to wintergreen by the additional frequencies not possessed by nitrobenzene. It follows that a small amount of methyl salicylate added to nitrobenzene should be perceived by the nose more easily than a small amount of nitrobenzene added to methyl salicylate, provided due allowance is made for the different absolute thresholds of the two substances.

The olfactory threshold concentration of each substance when dissolved in 'Nujol' was determined by a modification of the American Public Health Association method[3]. A dilute solution of each substance in 'Nujol' was prepared, serial dilutions were made, and 10 ml. of each solution were placed in a series of *B. O. D.* bottles. (These are 250-ml. bottles with ground stoppers and a funnel-like enlargement of the neck. They were washed and baked overnight at 105° C. before use.) Other bottles contained 10 ml. additions of pure 'Nujol'. The bottles were numbered but otherwise unmarked. Each bottle containing a solution was placed with two blanks, and the observ-

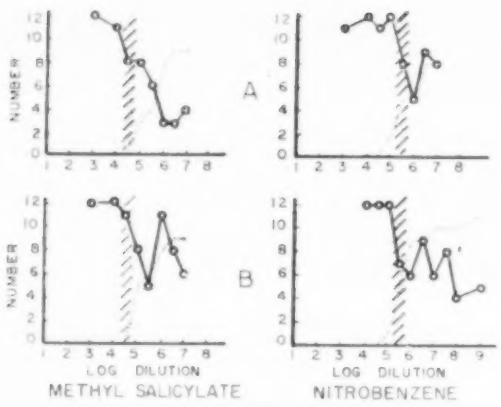

Fig. 1

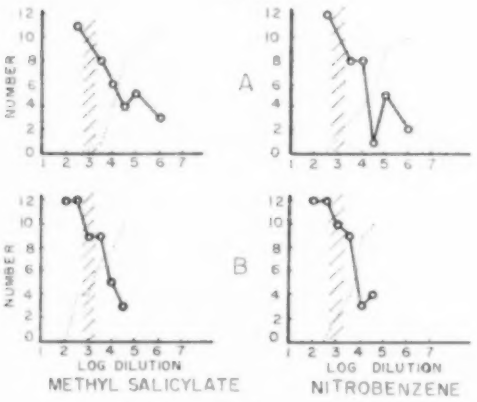

Fig. 2

ers were asked to smell all three and try to identify the 'one that was different'. The same twelve observers were used in all the experiments (except the last, Fig. 2*B*, when one new subject was used), which were all carried out in the same way and in the same room, and on four different days spread over a period of 10 weeks. The observers were given 45 sec. to smell each set of three bottles, 15 sec. to record the result, and then rested 60 sec. before smelling the next three. The strongest solutions were smelled first followed by the weaker ones in order, and all the solutions were made very dilute to minimize olfactory fatigue. The observers were told to guess if necessary, and to mark the guessed results.

The results of threshold determinations made on different days are shown in Fig. 1, *A* and *B*. The solid line shows the number of correct identifications of the 'odorous' bottle, and the dotted line the number of admitted guesses. The threshold concentration of methyl salicylate in 'Nujol' (indicated by the shaded area) is about 1 in 30,000, and that of nitrobenzene is about 1 in 300,000.

For the next experiment, a stock solution containing nitrobenzene in 'Nujol' at a concentration of 1 in 10,000 (= 30 × threshold) was made up and used in the pairs of blank bottles. The third bottle in each set contained the same base solution with a small addition of methyl salicylate. In a similar way, a base solution of methyl salicylate was made up containing 1 part in 1,000 (= 30 × threshold) and given small additions of nitrobenzene.

The observers then tried to determine the threshold concentration of one odorant in the presence of a constant amount of the other, with the results shown in Fig. 2, *A* and *B*. The threshold concentration for the perception of methyl salicylate in the presence of nitrobenzene was about 1 in 1,000, or 30 × the threshold for methyl salicylate by itself. For nitrobenzene to be smelled against a background of methyl salicylate, the threshold concentration was again about 1 in 1,000, but this is 300 × the threshold concentration for nitrobenzene alone.

Thus the wintergreen odour of methyl salicylate conceals the almond odour of nitrobenzene 10 times more effectively than the almond odour conceals the wintergreen odour. The effect is not large; but it is distinct, and it is in the direction predicted by the vibrational theory of odour.

I wish to thank Prof. E. S. W. Belyea and his students in the Department of Psychology of the University of British Columbia for carrying out the smelling tests.

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The Relation between Theoretical and Experimental Diamagnetic Susceptibilities for Aromatic Hydrocarbons

In calculations of the π-electron diamagnetic susceptibility of aromatic hydrocarbons by the method due to London[1], it is assumed that the calculated susceptibility χ^L is equal to the experimental anisotropy $\Delta\chi$. χ^L is, in fact, the susceptibility, due to delocalization of the π-electrons, in a direction perpendicular to the plane of the ring, which will be called the *z*-direction. In the semi-classical treatment due to Pauling[2] the same assumption was made, but Pauling went on to add to his calculated susceptibility the value obtained from Pascal constants[3] for the susceptibility in the plane, and he thus obtained the total susceptibility in the *z*-direction, χ_z. He compared his χ_z with the experimental values obtained from measurements of crystal susceptibilities. Later workers[4] have followed London rather than Pauling and sought to calculate $\Delta\chi$, not χ^L.

The identification of χ^L with $\Delta\chi$ has been criticized recently (refs. 4*a*, 4*b*), and Hoarau (ref. 4*b*) has suggested that the total anisotropy $\Delta\chi$ should be written:

$$\Delta\chi = \Delta\chi^\sigma + \Delta\chi^p + \chi^L \qquad (1)$$

where $\Delta\chi^\sigma$ and $\Delta\chi^p$ are the anisotropies due to the σ-bonds and the isolated $p\pi$-electrons, respectively. Support for Hoarau's view may be found in the work of Itoh, Ohno and Yoshizumi[5], who, in a calculation by the method of antisymmetrized molecular orbitals, obtained a value for χ^L equal to 49·6 per cent of the observed anisotropy for benzene, although Lykos and Parr[6] have suggested that most of the difference can be attributed to the approximation used in evaluating the resonance integral. A recent calculation I have carried out[7] using the

simplified self-consistent molecular orbital method[8] gave a value of χ^L of −33·26 (all susceptibility values quoted are $\times 10^{-6}$ c.g.s.e.m.u./mole) for benzene compared to the observed anisotropy[11] of −59·7. A contribution to the π-electron susceptibility in the z-direction, χ_z^π, of −1·35 per carbon atom was also obtained. This is due to the effect of the field on the isolated $p\pi$-electrons. Thus, for an aromatic hydrocarbon containing n carbon atoms, χ_z^π can be written :

$$\chi_z^\pi = -33{\cdot}26\rho - 1{\cdot}35n \qquad (2)$$

where ρ is the ratio of χ^L for the given hydrocarbon to χ^L for benzene. Values for ρ obtained by London[1] and by McWeeny (ref. 4c) may be used in equation (2), which provides a simple way of approximating to a full self-consistent molecular orbital calculation.

It is well known that diamagnetic susceptibilities can be written as the sum of a semi-classical term and a paramagnetic or high-frequency term of opposite sign[10]. The high-frequency term can be calculated for a polyatomic molecule only by making severe approximations[11], and its occurrence in $\Delta\chi$ makes the latter a difficult quantity to calculate. χ_z^π, however, does not contain a high-frequency term, and an empirical value for χ_z^π can be obtained from the experimental value for χ_z by using the equation :

$$\chi_z^\pi = \chi_z - \sum_i \chi_i \qquad (3)$$

where χ_i is the Pascal constant[3] for the ith atom, 6·0 for carbon and −2·9 for hydrogen. The high-frequency term occurs in Pascal's scheme for conjugated hydrocarbons as the constitutive correction for a carbon–carbon double bond[3], +5·5, which is, for this reason, not included in equation (3).

Table 1. Anisotropy ($\Delta\chi$) and π-Electron Susceptibility (χ_z^π)

Substance	$-\Delta\chi$ Exp.	$-\Delta\chi$ Calc.	$-\chi_z$ Exp.	$-\chi_z^\pi$ Exp.	$-\chi_z^\pi$ Calc.
Benzene	59·7[a]	(59·7)	94·6[a]	41·2	41·4
Naphthalene	114·0[b]	131[c]	169·0[d]	85·8	86·3
Anthracene	182·6[b]	206[c]	251·8[d]	139	134
Phenanthrene	166[b]	190[c]	240[b]	127	125
Pyrene	232·9[b]	266[c]	313·5[b]	189	170
Coronene	390[e]	585[f]	480[e]	301	358
Biphenyl	118·6[b]	112[f]	182[b]	81	78·4
p-Terphenyl	178·8[b]	163[f]	271·3[d]	123	115
p-Quaterphenyl	256[b]	214[f]	372[d]	176	152

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Table 1 shows calculated and experimental values for χ_z^π obtained from equations (2) and (3) respectively. For comparison the results of calculations of the London type for the anisotropy are compared with the experimental values. The agreement between theory and experiment for χ_z^π is clearly better than for $\Delta\chi$, thus supporting the views expressed here.

A more satisfactory treatment of anisotropies would be possible if experimental values for the contribution of the high-frequency term were known for some conjugated hydrocarbons. This contribution can be obtained from the rotational magnetic moment[12], and an interesting comparison of theoretical and experimental susceptibilities has been made for certain systems[13] the rotational magnetic moments of which are known. At present, however, for conjugated hydrocarbons the comparison of χ_z^π suggested here would seem to be more satisfactory than an attempt to calculate anisotropies.

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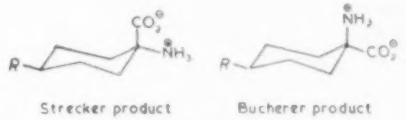
Alkylcyclohexanones in the Strecker and Bucherer Hydantoin Syntheses

The reaction of 2- and 4-alkylcyclohexanones in the Strecker and Bucherer hydantoin reactions leads to geometrically isomeric alkylcyclohexane-1-amino-1-carboxylic acids. Paper chromatographic analysis shows that the crude product of the Strecker reaction consists of one isomer only, while the main product from the Bucherer reaction has the alternative configuration. Assuming the configuration of the 4-alkyl derivatives to be indicated by the sluggish hydrolysis of the 1-amino-4-tert-butylcyclohexylcyanide hydrochloride[1] in the Strecker synthesis, then the Bucherer products must have the opposite configuration.



Strecker product Bucherer product

The evidence for the difference in identity is briefly : (i) The 4-methyl-, 4-ethyl-, 4-iso-propyl-, 4-tert.-butylcyclohexane-1-amino-1-carboxylic acids produced by the Strecker synthesis crystallize anhydrous from aqueous acetic acid, whereas the corresponding Bucherer products crystallize as hemi-hydrates from the same solvents. (ii) The melting points of the amino-acids and their derivatives are different :

Table 1

Cyclohexane carboxylic acid	Strecker product (melting point, °C.)	Bucherer product (melting point, °C.)
1-Amino-4-methyl-	356–360 (subl.)	305–310 (subl.)
1-Acetylamino-4-methyl-*	220–222	223–224·5
1-Benzoylamino-4-methyl-	209–210	234–236
4-Methyl-1-spiro-5'-hydantoin	215–216	281–282
1-Amino-2-methyl-	355–360	298–300
1-Acetylamino-2-methyl-	220–221	181–181·5
1-Benzoylamino-2-methyl-	174–175	196 (ref. 2)

* Mixed melting point, 170–185°

(iii) The infra-red spectra (in potassium chloride disks) are markedly different, particularly in the 6μ region, where the Strecker products alone give particularly well-resolved (amino-acid) bands. (iv) Different R_F values on Whatman No. 3*MM* paper using normal butanol–acetic acid–water as eluant.

These results indicate that the hydantoin synthesis does not proceed through the same intermediate amino-nitrile involved in the Strecker synthesis, as suggested by Bucherer[3].

Further work is in progress to confirm the configurations of these amino-acids and to elucidate the mechanisms of the reactions involved in their synthesis.

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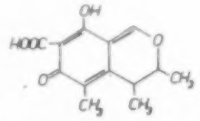
Chemical Structure of Citrinin

In our search for new antibiotics from fungi we have isolated a substance, *S*-52, a metabolic product of an unidentified *Penicillium*. From the results of paper-chromatographic investigations and from its other properties we believed the substance to be identical with citrinin. This has proved correct, since the infra-red spectra of the pure substance *S*-52 and of an authentic sample of citrinin (kindly provided by Dr. P. W. Brian, Akers Research Laboratories, Welwyn, Herts) were identical.

The measurement of the infra-red absorption spectra was carried out on a double-beam spectrophotometer *UR*-10 (*IR*-10), Zeiss, Jena. Sodium chloride cells 1·030 mm. thick were used and the concentration of citrinin was 4·5 gm./litre carbon tetrachloride.

Brown *et al.*[1] and Cramm[2] have proposed a chemical structure for citrinin according to the chemical reactions of this substance as follows:



(I)

The infra-red spectrum of citrinin (Fig. 1) indicates that the structure of citrinin differs from that proposed by these authors. Should citrinin have a free carboxylic group, this would be shown by an intense absorption band in the region above 1,700 cm.$^{-1}$, but this absorption band is absent.

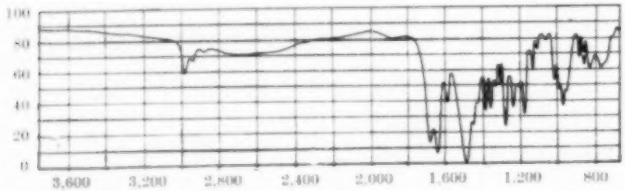
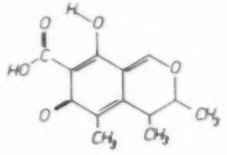


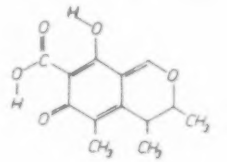
Fig. 1. Infra-red spectrum of citrinin. Ordinates, percentage absorption; abscissæ, wave-lengths

The absorption band in the region of 1,685 cm.$^{-1}$ belongs to the stretching vibrations of the C=O bond in the carboxylic group forming a strong chelate bond with the hydroxylic group situated in the ortho position[3,4]:



(II)

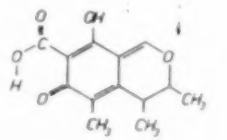
This is indicated also by the small intensity of the absorption band in the region of 3,700 cm.$^{-1}$. This is similar to the infra-red absorption spectrum of salicylic acid[3], where the absorption band in the region of 1,685 cm.$^{-1}$ belongs to the stretching vibrations of the C=O bond, forming a chelate bond. Salicylic acid can form only one chelate ring, but in the case of citrinin two can be formed:



(III)

The formation of one chelate ring as indicated by formula (II) would result in a weakening of the —OH bond in the carboxylic group and, in this case there would be a relatively intensive absorption band in the region of 950 cm.$^{-1}$ belonging to the bending vibrations of the —OH group in the carboxylic group.

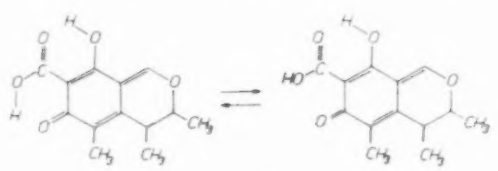
Should only one chelate ring, as indicated by formula (IV), be formed, the dilution of the electrons on the carbon atom of the carboxylic group would be compensated by the π-electrons of the double bond of the ring.



(IV)

In this case the —OH group on the ring would show itself by its +C-effect. By this the acidity of the hydrogen atom in the hydroxylic group would, of course, be greatly enhanced, and on the infra-red absorption spectrum a relatively intense absorption band would arise in the region of 3,600 cm.$^{-1}$.

As a relatively small absorption band is found in the region of 950 cm.$^{-1}$, and on the other hand a relatively broad absorption band belonging to the stretching vibrations characteristic for an intramolecular hydrogen bond appears in the region of 3,200 cm.$^{-1}$, we presume that citrinin is represented by formulæ (II) and (III) which are in equilibrium (V):



(V)

Table 1. Characteristic Infra-red Frequencies of Citrinin

Frequency (cm.$^{-1}$)	Group	Nature of vibration
3,200		ring vibration (chinoid system)
2,935, 2,870	CH_3	stretching C—H
1,685	C=O	stretching C=O
1,640	C=C	stretching C=C
1,600	C=H	stretching C—H (unsaturated)
1,480	C—H	bending C—H (asymmetrical)
1,380	C—H	bending C—H (symmetrical)
1,310	C—O	stretching C—O
1,180	—C—O—C	stretching —C—O—C
1,130	—O—	ring vibration
950	—OH	bending (in —COOH group)

The characteristic vibrations of the individual groups of atoms in the molecule of citrinin are presented in Table 1.

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BIOCHEMISTRY

Imidazole Acrylic Acid Excretion in Kwashiorkor

Children who are suffering from severe kwashiorkor (protein-calorie malnutrition) lose a large proportion of their tissue solids[1]. Earlier work[2] has shown that in spite of a very low protein intake a relatively large amount of nitrogen is still excreted in the urine. The amount increases with the severity of the illness, which strongly indicates an endogenous origin. A considerable part of the nitrogen cannot be accounted for as urea, ammonia, free amino-acids, peptides, creatine, creatinine or uric acid. Evidence was obtained for the presence of nitrogenous material which absorbed ultra-violet light in the region 268–274 mμ. The fractionation of the material and the isolation of one of its components form the basis of this communication.

Initial separation was achieved by paper chromatography. 50–100 μl. of urine were applied to Whatman No. 1 paper and the chromatogram was run in *n*-butanol/formic acid/water (77 : 10 : 13). After drying, the chromatogram was examined in ultra-violet light by the method of Markham and Smith[3], and ten abnormal compounds were detected which appear in the urine of severe cases of kwashiorkor and disappear on successful treatment. The compound with the largest absorption, temporarily called *F*, has been isolated by the following method and identified.

Two litres of urine were shaken for 30 min. with 100 gm. of activated charcoal. After washing with 2 l. of distilled water, the absorbed material was eluted twice with 2 l. of 50 per cent v/v acetic acid. The eluate was concentrated by distillation under reduced pressure at 60° C. and finally in a vacuum desiccator. The resultant dark brown tar was redissolved in ammonium formate at *p*H 11 and aliquots were applied to a 'Dowex-1' formate column. The column was first eluted with 0·01 *M* ammonium formate at *p*H 6 followed by 0·01 *M* formic acid which gave a good separation of the compound *F*. The fractions were combined, concentrated by distillation under reduced pressure and taken to dryness *in vacuo*. The material still contained some tarry impurity and was therefore passed again through the 'Dowex-1' column. The product was analysed by paper chromatography, which showed that it contained in addition to the major component a small amount of a further compound. The material was dissolved in hot acetic acid and insoluble substances removed by filtration. The filtrate was evaporated to dryness and redissolved in 4 ml. 20 per cent v/v acetic acid. On addition of diethyl ether, almost colourless needle-shaped crystals were obtained. Recrystallization from water gave a chromatographically pure product.

The crystals contained carbon, 52·3; hydrogen, 4·42; nitrogen, 20·2 per cent, indicating the formula $(C_3H_3ON)_x$. Unfortunately the material was too insoluble in camphor for a molecular weight determination. The ultra-violet absorption spectra (absorption maxima 268 mμ in 0·1 *N* hydrochloric acid and 287 mμ in 0·1 *N* sodium hydroxide) had suggested that compound *F* might be a substituted xanthine, but the minimum molecular formula for a purine on the pattern (C_3H_3ON) would be $C_{12}H_{12}O_4N_4$ and the molar extinction coefficient for this compound in hydrochloric acid would be $3{\cdot}8 \times 10^4$, which is very high. A compound that was known to have a high molar extinction coefficient was imidazole-acrylic acid (urocanic acid), and its formula would fit the analysis of compound *F* if the molecular weight corresponded to twice the empirical formula.

The ultra-violet spectra of the isolated material were identical with those of a sample of imidazole-acrylic acid obtained from Roche Products, Ltd. (Table 1). The material melted at 224° C. and the reference sample at 225° C.; the mixed melting point was 224·5° C. The infra-red spectra of both substances in potassium chloride powder were identical, and they had the same R_F values when chromatographed

Table 1. Ultra-Violet Absorption of Compound *F* and Imidazole-Acrylic Acid

Solvent	Compound *F*		Imidazole–Acrylic acid	
	Absorption maximum (mμ)	$E^{0.001\%}_{1\text{ cm.}}$	Absorption maximum (mμ)	$E^{0.001\%}_{1\text{ cm.}}$
0·1 *N* hydrochloric acid	268	1·49	268·5	1·49
Water (*p*H 6·6)	265	1·26	265	1·24
Water (*p*H 8·1)	278	1·40	278	1·38
0·1 *N* sodium hydroxide	286·5	1·18	287	1·17
N sodium hydroxide	307	1·51	307	1·50

on paper in four different solvents: (1) *n*-butanol saturated with water, containing 1 per cent ammonia (s.g. 0·880), R_F 0·06; (2) *n*-butanol/acetic acid/water (63 : 10 : 27), R_F 0·47; (3) *n*-butanol/formic acid/water (77 : 10 : 13), R_F 0·50; (4) *iso*propanol-hydrochloric acid[4], R_F 0·64.

Although imidazole-acrylic acid has been tentatively identified in trace amounts in human urine[5], it has not previously been isolated from urine. In 12 severe cases of kwashiorkor, the average amount excreted was 28 mgm./12 hr. (range 10–80 mgm.). Only very small amounts have been found in the urine of early cases, and none in cases that have been successfully treated for a week or ten days.

Imidazole-acrylic acid is a known metabolite of histidine, and, in rats treated with ethionine[6], the acid has been found in the urine after intraperitoneal injection of L-histidine-2-^{14}C. The origin in the children with kwashiorkor has not yet been determined. It may be histidine that is released by tissue breakdown: if the breakdown is excessive, the enzyme system normally responsible for metabolism beyond the stage of the acid may be overwhelmed.

The possibility of using the presence of the acid as an aid to the diagnosis of kwashiorkor, and other details of clinical significance, will be described elsewhere.

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Micellar Solubilization of Fatty Acids and Monoglycerides by Bile Salt Solutions

Bile salts were recognized as detergents some years ago[1], but few investigations have been done on their detergent properties under physiological conditions. Aqueous solutions of detergents are known to form molecular aggregates called micelles[2]. These form above a critical micellar concentration (CMC) and can solubilize water-insoluble materials. Using synthetically prepared[3], chromatographically pure[4] bile salts, I have investigated the micellar solubilization of pure fatty acids and monoglycerides in bile salt solutions, under conditions simulating those present in human small intestinal content during fat absorption[5].

For lipids with melting point above 37°, an excess of radioactive material was incubated in bile salt solution with shaking, and the amount of solubilized lipid determined after filtration. For lipids, such as α-mono-olein, which form liquid crystalline suspensions with bile salts when present in excess, the maximum amount of lipid which could be solubilized was determined turbidometrically[6]. All incubations were done at 37°, for 96 hr., with bile salt solutions 0·15 *M* (sodium ions), at a *p*H of 6·3, and at physiological concentrations[7]. The resulting micellar solutions

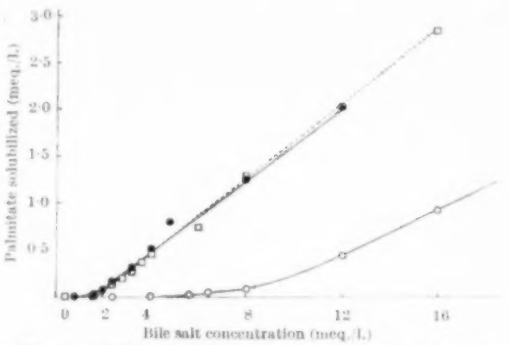

Fig. 1. Solubilization of palmitate by conjugated bile salts; *p*H 6·3, 37° C., 0·15 *M* sodium ions. ○, taurodeoxycholate; ●, glycodeoxycholate; □, taurocholate

were stable and transparent, without turbidity or opalescence.

Under these experimental conditions and in the absence of bile salts, no ordinary carboxylate soap is sufficiently soluble to form a micellar solution. The unconjugated bile salt deoxycholate is quite insoluble at this *p*H and sodium concentration, and cholate forms unstable solutions from which cholic acid precipitates. Thus stable micellar solutions under conditions normally present in small intestinal content seem possible only with conjugated bile salts (and possibly lysolecithin). Conjugation of deoxycholate and cholate with glycine or taurine lowers the *pK* and increases the solubility under these experimental conditions.

Palmitate solubilization begins at a well-defined bile salt concentration, the critical micellar concentration, and the amount solubilized rises linearly with increasing bile salt concentration (Fig. 1). The critical micellar concentration is about 7 meq./l. for the trihydroxy-bile salt, taurocholate, and about 1·6 meq./l. for the dihydroxy-salts, taurodeoxycholate and glycodeoxycholate. For a fixed bile salt concentration, the amount of fatty acid solubilized is directly proportional to the sodium ion concentration.

α-mono-olein solubilization begins at a lower critical micellar concentration than palmitate (Fig. 2) and the solubilization curves rise much more steeply. The critical micellar concentration for α-mono-olein solubilization is about 5 meq./l. for taurocholate and 0·8 meq./l. for glycodeoxycholate and taurodeoxycholate. α-Mono-olein and α-mono-linolein form myelin figures in bile salt solutions, which diffuse into the bile salt solution, rapidly forming a transparent micellar solution rich in lipid. α-Mono-palmitin, however, does not form myelin figures, and the critical micellar concentration and amount solubilized are almost identical to those of palmitate under these conditions.

A bile salt solution containing previously solubilized α-mono-olein dissolves far more palmitate than in the absence of mono-olein, and solubilization begins at a much lower bile salt concentration.

These results seem relevant to the observation that β-mono-glycerides and fatty acids are the normal end-products of pancreatic lipolysis during fat digestion[8], and that the β fatty acid of most dietary triglycerides is unsaturated[9]. Micellar solubilization by conjugated bile salts of unsaturated mono-glycerides and fatty acids may be the usual pathway of the products of pancreatic lypolysis, and it is possible that lipids may

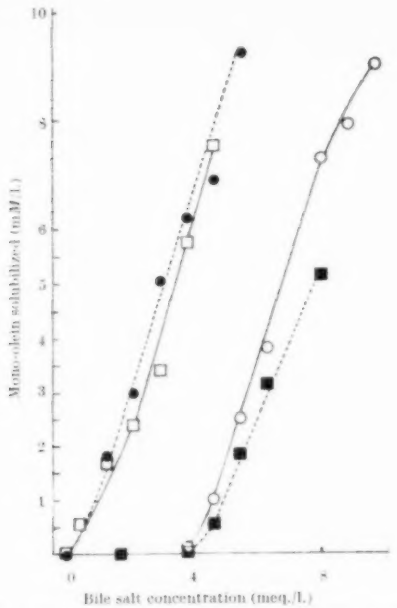

Fig. 2. α-Mono-olein solubilization by bile salts; *p*H 6·3, 37° C., 0·15 *M* sodium ions. ●, glycodeoxycholate; ○, cholate; □, taurodeoxycholate; ■, taurocholate

be absorbed in this form. It is of interest that the critical micellar concentrations of the bile salt solutions in these simple *in vitro* systems correspond closely to the lowest bile salt concentrations enhancing triglyceride synthesis in the work of Dawson and Isselbacher, who used preparations of intact small intestine[10].

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Origin of the Potential Difference in the Intestinal Epithelium of the Turtle

WHILE we were looking for a suitable preparation to investigate the absorption of amino-acids in the digestive tract, we were impressed by the fact that the potential difference across the epithelium of the small intestine of various species is consistently lower (around 1 mV.) than the potential difference existing across the gastric mucosa or the colon (about 30 mV.). In order to throw some light on this observation we have first measured the flux of sodium across the isolated epithelium of the small intestine and the colon of the turtle *Testudo hermanni* J. F. Gmelin. We have chosen this species because it is quite easy to strip the muscle layers off the epithelium. The method used is described elsewhere[1]. Both sides of the isolated epithelium are bathed with saline having the following composition: sodium chloride 113 m*M*; potassium chloride 1·9 m*M*; calcium chloride 0·45 m*M*; phosphate buffer *p*H 7·0, 1·5 m*M*. Table 1 gives the results obtained. It can be seen that there is an active transport of sodium from the mucosal to the serosal side of the preparation in both small intestine and colon. The fact that the values of the short-circuit current are smaller than the values of the net flux means that a cation must be transported actively from the serosal to the mucosal side, or that an anion must be transported actively in the opposite direction. It is also interesting to note that the values of the flux are higher in the small intestine than in the colon and that dinitrophenol inhibits, at least partially, both influx and outflux in the small intestine. This could indicate that part of the outflux of sodium across the small intestine is due to active transport. Let us examine now the effect of a modification in sodium and potassium concentrations on the potential difference across both intestine and colon (Table 2). In these experiments chloride is generally replaced by an equivalent amount of the non-penetrating sulphate anion. Na/10 means a saline containing 10 times less sodium than the physiological saline. Sodium is then replaced by an iso-osmotic amount of sucrose. K × 10 means a saline containing 10 times more potassium than the physiological saline. It can be seen that:

Table 1. INFLUX AND OUTFLUX OF SODIUM ACROSS THE ISOLATED EPITHELIUM OF THE SMALL INTESTINE AND THE COLON IN THE TURTLE *Testudo hermanni* J. F. GMELIN

The epithelium is bathed with a physiological saline on both sides. Results obtained when 2,4-dinitrophenol (DNP) is applied are also given. The fluxes, the net flux and the short-circuit current are expressed in m.coulomb cm.$^{-2}$.H^{-1}. *C*, control. Dinitrophenol concentration, 0·1 m*M*. Experimental periods, 1 hr.

	Influx	Outflux	Current	Net flux
	Small intestine			
C	492	401·4	41·6	90·6
C	540·4	437·1	40·1	103·3
Dinitrophenol	492	329	32·2	163
	419	314	28·5	105
	Colon			
C	174	42·4	104	131·6
C	121·6	34·7	61	86·9
Dinitrophenol	42·4	28·9	33	13·5
	50·2	50·2	13	0

(1) The replacement of chloride by sulphate is without any effect on the potential difference across the small intestine, contrary to the situation in the colon where the potential difference increases. A decrease in sodium concentration in the mucosal solution results in the inversion of the potential difference across the small intestine. In the colon we observe a decrease in potential difference (experiment *B*).

(2) If one then increases the potassium concentration, the potential difference decreases in the small intestine, while it stays constant in the colon (experiment *H*).

Table 2. Effect of sodium and potassium concentrations on the potential difference across the isolated epithelium of the colon and the small intestine in the turtle *Testudo hermanni* J. F. Gmelin
The sign refers to the serosal side

Experiment	Small intestine		Potential difference (mV.)	Colon		Potential difference (mV.)
	Mucosal	Serosal		Mucosal	Serosal	
B	RCl RSO_4 RSO_4 Na/10	RCl RSO_4 RSO_4	1 1 −26	RCl RSO_4 RSO_4 Na/10	RCl RSO_4 RSO_4	20 45 25
C	RSO_4 RSO_4	RSO_4 RSO_4–Na/10	1 30	RSO_4 RSO_4	RSO_4 RSO_4 Na/10	30 60
H	RSO_4 RSO_4 Na/10 RSO_4 Na/10–K/10	RSO_4 RSO_4 RSO_4	1 −26 −12	RSO_4 RSO_4 Na/10 RSO_4 Na/10–K/10	RSO_4 RSO_4 RSO_4	57 48 48
I	RSO_4 RSO_4 RSO_4	RSO_4 RSO_4 Na/10 RSO_4 Na/10–K/10	1·5 20 12	RSO_4 RSO_4 RSO_4	RSO_4 RSO_4 Na/10 RSO_4 Na/10–K/10	13 21 19

(3) In sulphate saline, a decrease in sodium concentration in the serosal solution increases the potential difference across both small intestine and colon (experiment *C*). If the potassium concentration is then increased, the potential difference decreases in both small intestine and colon (experiment *I*).

The observations reported in Table 2 suggest the following conclusions. As the replacement of chloride by sulphate in the solutions bathing both sides of the colon produces an increase in potential difference, it is clear that this epithelium is relatively impermeable to sulphate. The epithelium of the small intestine is equally permeable to chloride and sulphate, since the replacement of chloride by sulphate has no effect on the potential difference. This result could also be explained if one postulates that the epithelium, although impermeable to sulphate, is permeable to potassium and sodium. This possibility is most likely to be correct as the other results demonstrate that the epithelium is permeable to sodium and potassium. Moreover, using sulphur-35 as tracer, we have been able to show that the permeability coefficient for sulphate in frog skin, turtle colon and intestine are of the same order of magnitude (unpublished results). Nevertheless, as we have found that the replacement of chloride by sulphate does not affect the magnitude of the potential difference appreciably when the sodium concentration is modified, this would suggest that the passive permeability of the small intestine to chloride is low.

The small spontaneous potential difference existing across the small intestine is related to the concentrations of sodium and potassium in the mucosal and serosal solutions: it is thus clear that both mucosal and serosal sides of the epithelium are permeable to these ions. On the contrary, in the colon the mucosal side is permeable to sodium, but impermeable to potassium, while the serosal side is permeable to both ions.

It is obvious from the results reported here that the distribution of the permeability characters in the small intestine is different from that in the colon. The organization and the distribution of the permeability characters is therefore an important aspect of cell differentiation. A purely speculative scheme has been proposed to explain the possible evolution of the permeability characters in the epithelial tissues[2]. According to this hypothesis, the primitive stage would be characterized by a mechanism of active transport located at both inner and outer borders of the cell. The cell would then evolve toward an asymmetry by losing the active transport mechanism at one of the borders. The results reported here give some experimental support to this conception.

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Constituents of *Lagerstroemia Flos-reginae* Retz.

For many years people of the Philippines have used certain parts of a tree (*Lagerstroemia Flos-reginae* Retz.) as an aid in the lowering of blood sugar[1,2]. The drug, commonly called 'banaba', is usually administered in the form of an aqueous 20 per cent decoction prepared from the leaves. While the drug has been employed for many years and pharmacological studies have been made using extracts of the drug[3,4], very little information has appeared in the literature concerning its constituents.

Dried leaves, obtained from an authentic source, were used in this investigation. To ensure that our material possessed physiological activity, 20 per cent decoctions were prepared. These, with and without tannins, were administered orally via stomach tube to rabbits. The dose was 10 ml. of 20 per cent decoction per kgm. of body-weight. Following administration of the drug, blood sugar determinations were made at 2-, 4-, and 6-hr. intervals using the Nelson–Somogyi procedure[5]. Results revealed that the leaves possessed hypoglycæmic properties as the average blood sugar was lowered 25 mgm. per cent after 4 hr., which was the peak time of activity. The results were essentially the same regardless of the presence or absence of tannins.

Determinations for the presence of therapeutically active compounds commonly found in plants were carried out. Alkaloid analysis was performed using Wall's method[6,7]. Flavonol determinations were carried out using Bryant's method[8], rutin being used as a control. Analysis for sterols was carried out with Liebermann–Burchard and Salkowski tests. Several methods of analysis for glycosides were employed, including (*a*) acid hydrolysis of an 80 per cent alcohol extract and subsequent analysis for reducing sugars;

(*b*) hydrolysis of an aqueous extract with β-glucosidase; (*c*) the use of ion exchange according to the method of Khym and Zill[9]. Results of the preceding tests were negative for the presence of alkaloids, glycosides, sterols and flavonols. The presence of tannins in banaba as indicated by Garcia was substantiated, and we have done some work on the nature of the tannins present.

It was suggested by Garcia[1] that perhaps some type of 'insulin-like' material might be responsible for the hypoglycæmic activity. Therefore we checked carefully for the presence of amino-acids in our extracts. Aqueous extracts were purified by Plaisted's method[10], which involves a desalting technique using ion exchange. Portions of the purified extracts were then spotted on Whatman No. 1 filter paper for chromatographic analysis. Four solvent systems proved to be the most efficient. These were: (1) *n*-butanol/glacial acetic acid/water (12 : 3 : 5); (2) *n*-butanol/pyridine/water (1 : 1 : 1); (3) *tert.* butanol methylethylketone/diethylamine/water (2 : 1 : 2 : 2); (4) phenol/water (4 : 1). The presence of amino-acids was detected with ninhydrin. Amino-acids found were alanine, *iso*leucine, α-aminobutyric acid and methionine, the latter present in much higher amounts than the others. Purified extracts were also subjected to paper chromatographic analysis using the method of Moffat and Lytle[11]. Results of the latter procedure confirmed the presence of the above-named amino-acids.

From the results obtained it appears that constituents responsible for hypoglycæmic activity are not from those classes of secondary constituents commonly found in plants.

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A New Photo-reaction between some Furocoumarins and Flavin Mononucleotide

The photosensitizing properties on the skin of some furocoumarins have been studied extensively by us since 1953[1] and later by other workers[2]. While the relationships of chemical structure to photodynamic effects are well known, the mechanism of action of these substances is at present not clear, in spite of the fact that xanthotoxin is used therapeutically for leucodermia. Recently, Pathak and Fellman[3] pointed out interesting relationships between activating and fluorescent wave-lengths and the photodynamic properties of many furocoumarins. Furthermore, we have been able to show[4] that furocoumarins do not operate by a photo-oxidative process on a protein substrate as do other known photodynamic substances (hæmatoporphyrin, hypericin, erythrosin, rose bengal, benzpyrene, etc.[5]).

We report here the results of research work which started from the observation, about a year ago, that some furocoumarins react with flavin mononucleotide on ultra-violet irradiation. A preliminary report of this work was given on May 22, 1960, at the meeting of the Istituto Veneto di Scienze, Lettere ed Arti, Venice.

Aqueous ethanolic solutions of equimolecular mixtures of flavin mononucleotide and of a furocoumarin (psoralen, xanthotoxin or bergapten) were irradiated by a Philips lamp (*HPW* 125) of principal wave-length 3655 Å. By paper chromatography with *n*-butanol acetic acid/water (4 : 1 : 5) as eluant, new spots are detectable, which do not appear when flavin mononucleotide and furocoumarins are irradiated separately. There are spots of yellow colour and yellow fluorescence at low R_F values (0·15–0·22), and spots with violet or blue-violet fluorescence at high R_F values (0·85–0·90). The intensity of these new spots increases up to a maximum with the time of irradiation.

The ethereal extract containing the derivatives with violet and blue-violet fluorescence, which are formed on irradiation of a mixture of flavin mononucleotide and bergapten, was chromatographed on a column of silica gel, using water as the stationary phase and benzene or benzene–ethyl ether mixtures as the moving phase. So far three new compounds have been isolated in small quantity: substance *a*, $C_{14}H_{14}O_6$, melting point 153°, with violet fluorescence; substance *b*, $C_{12}H_{10}O_6$, melting point 178°, with violet fluorescence; substance *c*, $C_{12}H_8O_5$, melting point 208°, with grey-blue fluorescence. Compound *a* is an ethyl ester giving, by saponification, an acid identical to compound *b*. All these compounds appear to have coumarinic structure, showing that the furanic ring of the bergapten undergoes modifications. Further work is in progress for the elucidation of these substances and of those formed in the photoreaction between flavin mononucleotide and psoralen or xanthotoxin.

It seems that this photo-reaction does not take place appreciably when flavin adenine-dinucleotide is used. In fact, the irradiation of solutions of the latter containing equimolecular quantities of psoralen, xanthotoxin or bergapten did not give significant variations in the activity of flavin adenine-dinucleotide as coenzyme for D-amino-acid-oxidase, when determined by Warburg and Christian's method[6].

It has not been possible, hitherto, to say if the *in vitro* reaction between flavin mononucleotide and some furocoumarins could explain the mechanism of the photodynamic activity on the human and guinea pig skin by furocoumarins. However, the following results have to be considered carefully:

(1) We found a strict parallelism between chemical reactivity and biological action, that is, only the photodynamically active furocoumarins (for example, psoralen, xanthotoxin, bergapten, allobergapten, angelicin, 4′-methyl-psoralen, 5-*iso*propyloxy-psoralen, 3-methyl-xanthotoxin, 3,4′-dimethyl-xanthotoxin, 4,5′-dimethyl-xanthotoxin, 4,4′-dimethyl-psoralen) gave new compounds when irradiated with solutions of flavin mononucleotide, as observed by paper chromatography. No new spot is detectable when photodynamically inactive derivatives were

used (isopimpinellin, xanthotoxol, bergaptol, 4′,5′-dihydropsoralen, 4′-phenyl-4-methyl-psoralen, 3,4-dihydropsoralen, 4′,5′-dihydrobergapten, 4-methyl-5′-phenylxanthotoxin, thioxanthotoxin, erniarin, citropten, seselin, ethyl ester of psoralen-5-oxyacetic acid, etc.).

(2) There are also indications that flavin mononucleotide could give some protection *in vivo*: a batch of guinea pigs (average weight 450 gm.) was treated with bergapten (200γ/4 cm.² of area); an Osram *HWA* 500-W. lamp was used as a source of radiation, with a total exposure of 60 min., and the distance between the lamp and the irradiated skin was kept constant at 30 cm. A very large dose of flavin mononucleotide (50 mgm. immediately after irradiation and 4 doses of 20 mgm. each at 12-hr. intervals) was injected subcutaneously at a distance from the place of application of bergapten and the irradiated zone. In a few cases erythema did not appear, in some animals a lighter erythema occurred, and in others erythema was delayed, compared with a control group of guinea pigs, irradiated in the same conditions and not injected with flavin mononucleotide. We emphasize that the amount of flavin mononucleotide necessary to give some protection was accompanied by a toxic effect.

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Gastric Esterases of Pigs

There has been considerable controversy as to the existence of a gastric lipase since Volhard[1] discovered the breakdown of fat in the stomach. Many authors have ascribed this phenomenon to regurgitated pancreatic or duodenal activities, but others believe that the stomach produces a factor which is active in the normal breakdown of fats.

During investigations of the esterolytic activities of tissues of the alimentary tract of pigs[2], using a *p*H-stat method, it was shown that the fundic mucosa had no ability to hydrolyse triolein, which is a typical lipase substrate. This confirms the findings of Cherry and Crandall[3] and of Schonheyder and Volqvartz[4]. It thus seems likely that the reported gastric hydrolyses of fats are not due to an enzyme produced in the fundic mucosa.

Preliminary investigations revealed that the fundic mucosa had low activity towards simple esters, such as 'Tween 20', ethyl acetate and triacetin. The *p*H optima of the hydrolyses of these three compounds were 8·8, 6·5 and 7·3, respectively. Such high *p*H optima suggest that these enzymes are of no practical use in the normal digestive processes of the animal, since the normal *p*H of the stomach content is much below this figure.

Detailed investigations of the behaviour of these systems in the presence of inhibitors were prohibited by the very low activities present. It was not found possible to use homogenates of the fundic mucosa containing more than 200 mgm. wet tissue/ml. because of the high viscosity of the extracts, and triacetin, which was hydrolysed at the greatest rate by this tissue, only produced 5 micro-moles of acid min./gm. wet tissue.

However, we were able to show that the hydrolyses of all three substrates were inhibited by NN′ di-*iso*-propyl phosphodiamidic fluoride (mipafox), and that the hydrolyses of ethyl acetate and triacetin were also inhibited by *p*-chloromercuribenzoate (*p*-C.M.B.) (see Table 1).

Table 1. Inhibition of Hydrolysis of Triacetin (per cent)

Inhibitor	Concentration	'Tween 20'	Inhibition ethyl acetate	Triacetin
Mipafox	2×10^{-4} *M*	100	—	—
	$1{\cdot}5 \times 10^{-4}$ *M*	—	74	49
p-C.M.B.	2×10^{-4} *M*	0	—	—
	$1{\cdot}5 \times 10^{-4}$ *M*	—	5	22

The inhibition of the hydrolysis of triacetin by mipafox and *p*-C.M.B. was additive, suggesting action on two active centres, and possibly indicating the participation of two enzymes.

Calcium ions activate the hydrolysis of 'Tween 20', but inhibit the hydrolysis of ethyl acetate and triacetin. This inhibition can be lessened by adding ethylenediamine tetraacetic acid, which removes calcium ions.

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Effect of Water-soluble Polymers on Nitrate Reductase Activity

Several years ago Whitaker[1] observed that the presence of small quantities of bovine serum albumin, β-lactoglobulin, and other proteins enhanced the activity of a cellulase preparation obtained from culture filtrates of *Myrothecium verrucaria* when insoluble substrates were used. Tracey[2] found a similar effect in the stimulation by cow serum of chitin hydrolysis by chitinase. More recently, activation by polymers has been observed in homogeneous aqueous enzyme systems. The action of liver diaphorase has been reported[3] to be enhanced by bovine serum albumin and polyvinylpyrrolidone while polysaccharides, particularly starch, have been shown[4] to increase the activity of horse-radish peroxidase. These findings suggest that the *in vitro* enhancement of enzymic activity by non-catalytic polymeric materials may be a phenomenon of broad biological significance.

We discovered a new example of this 'polymer effect' while studying the metabolism of inorganic nitrogen. It was observed that the enzymic activity of nitrate reductase preparations obtained from the mould *Neurospora crassa* (5297.4) and purified by ammonium sulphate fractionation and column chromatography on hydroxyl apatite[5] is stimulated appreciably by several polymeric materials, notably by methyl cellulose and polyvinylpyrrolidone. We also tested the effect of several chelating agents, sugars, amino-acids, and other low-molecular-weight additives on the activity of the chromatographed enzyme. Reagent-grade materials were used wherever possible. Nitrate reductase activity was determined by colorimetric analysis of the rate of enzymic nitrite formation at 25° C. under zero-order reaction conditions. All additive materials were tested for interference with this analysis[7] and appropriate corrections made where necessary in calculating the nitrate reductase activities listed in Table 1.

Table 1. Effect of Additives on the Activity of Purified Nitrate Reductase

Additive	Concentration of enzyme protein (μgm./ml.)	Relative enzyme activity
None	122	100
Egg albumin	61	94
Dextran, clinical	61	94
Gelatin	61	140
Gum acacia	61	108
Methyl cellulose (100 cp.)	61	164
Polyvinylpyrrolidone (*K*-30)	61	149
Soluble starch	61	125
DL-Alanine	122	93
Creatine	122	89
L-Cysteine	122	80
Adenosinetriphosphate	122	47
L-Leucine	122	74
Ethylene dinitrilotetraacetic acid	122	105
Sucrose	122	90
D-Glucose	122	89
Glycerol	122	85
Sodium deoxycholate	122	116
Tris(hydroxymethyl)aminomethane	122	80
Reduced glutathione	122	110
Diglycylglycine	122	98

Assay mixtures: 0·50 ml. additive in 0·1 *M* phosphate, final *p*H 7·0; 0·08 ml. $1{\cdot}25 \times 10^{-4}$ *M* flavin adenine dinucleotide; 0·02 ml. 1·0 *M* potassium nitrate; nitrate reductase (specific activity 300–1,000) dissolved in 0·32 ml. neutral phosphate, 0·1 *M*. Assay reaction initiated by adding 0·08 ml. 2×10^{-2} *M* reduced triphosphopyridine nucleotide.

Concentrations of additives (polymers: 5 mgm./ml., other additives: $1{\cdot}0^{-2}$ *M*) were chosen arbitrarily. Subsequent observations indicated that for methyl cellulose, at least, maximal enhancement of nitrate reductase activity is obtained by considerably lower polymer concentrations.

Among the polymers tested, egg albumin and dextran are conspicuous in their failure to enhance the reaction-rate of nitrate reductase. Thus it appears that a macromolecule must be endowed with specific physico-chemical characteristics in order to exercise a 'polymer effect' on a given enzyme system.

With the exception of sodium deoxycholate, none of the low-molecular weight substances examined produced a significant enhancement of enzymic activity. At the concentrations used, most of these materials were in fact inhibitory. The 'polymer effect' is exerted by the polymer molecule and not by its monomers. This is seen by comparing the action of glucose, alanine, cysteine and leucine with that of starch and gelatine, respectively.

Since neither ethylenediamine tetraacetic acid nor *tris*(hydroxymethyl)aminomethane at concentrations of 10^{-2} *M* enhances nitrate reductase activity, chelation of inhibitory trace metals possibly present in the assay mixtures does not provide a basis for the 'polymer effect'. A kinetic explanation (Kamen, M. D., personal communication) has been suggested based on the premise that certain polymer materials may be capable of reversing a possible product-inhibition of the enzyme by physicochemical interaction with the nitrite ions formed. Kinetic studies[5] have shown, however, that at concentration-levels usually reached during assay, nitrite ion has no effect on the zero-order reaction-rate of the enzyme.

The well-known property of dissimilar polymeric materials to form binary aqueous systems[8] has been considered as a possible basis for the 'polymer effect'. The interfaces of such systems may exert an orienting effect on the enzyme molecule which could result in a more efficient catalytic system. Mixtures of methyl cellulose (5 mgm./ml.) and semi-purified nitrate reductase protein (8 mgm./ml.) slowly separate on standing into two aqueous phases. This phase separation is not observed when bovine serum albumin is substituted for the enzyme. At concentration-levels (50–200 μgm. protein/ml.) prevailing during enzyme assay such a phase separation was not found spectrophotometrically nor was it expected on the basis of Albertsson's results[8] on the composition of aqueous binary polymer systems.

Whitaker[2] noted that with less-pure preparations of cellulase the stimulation given by extraneous proteins is reduced. He attributed this observation to the presence of non-enzyme protein in the enzyme preparation. We encountered the 'polymer effect' on nitrate reductase activity only after the enzyme had undergone considerable purification.

These observations suggest to us that purification removes auxiliary substances normally associated *in vivo* with these enzyme systems, which provide a physicochemical environment permitting maximal catalytic activity. Such a physicochemical environment is provided apparently *in vitro* by certain polymer materials.

It may be argued that the presence of macromolecules such as methyl cellulose helps to prevent surface denaturation of the enzyme. Protective effects of this kind are well known, as exemplified by the protection of glutathione reductase activity by bovine serum albumin[10]. We observed, however, that the percentage increase in apparent nitrate reductase activity due to the presence of a fixed amount of methyl cellulose remains constant over a considerable range of enzyme-levels, down to protein concentrations of less than 4 μgm./ml. Furthermore, the presence of methyl cellulose has no effect on the gradual loss of enzyme activity observed when dilute purified nitrate reductase preparations are exposed to room temperature. Thus the 'polymer effect', as demonstrated by the example of methyl cellulose, promotes, but does not protect, enzymic activity.

In view of this evidence, we are inclined to believe that many macromolecules of varied structure possess physicochemical characteristics which render them capable of enhancing the *in vitro* catalytic activity of a number of enzyme systems. While the mechanism of this enhancement is still the subject of speculation[4], 'polymer effects' on enzymic efficiency should no longer be regarded as isolated phenomena. Their existence must be taken into consideration when dealing with purified enzyme systems.

Further work is in progress, and a detailed report will be published later.

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Activation of Hurain by Bivalent Iron

Hurain[1], the active principle of the sap of jabillo trees (*Hura crepitans*) which is responsible for its proteolytic action, apparently represents a proteinase with special chemical properties differing from those so far known for this class of enzymes. During purification and assay of the enzyme, it was found that the enzymatic activity of hurain is greatly affected by metal ions.

Experimental results, to be described in this preliminary communication, have been performed with crude enzyme obtained as a dry, almost white powder from the tree sap by cutting the bark and centrifuging, dialysing and freeze-drying the pooled samples. Proteolytic activity was determined by present techniques[2-5]. The enzyme preparation shows certain activity on hæmoglobin and egg albumin (Fig. 1), gelatine and Witte's peptone[1], without further additions; maximal activity is reached, however, only when bivalent iron ions are added (Table 1).

The crude hurain preparation was found to act also on a synthetic substrate. Hurain slowly hydrolyses

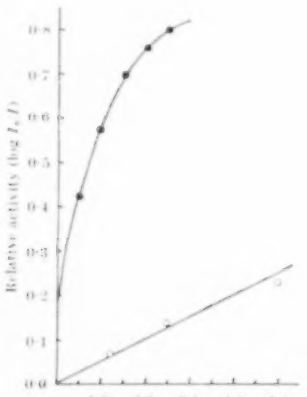

Fig. 1. Relative activity of crude hurain on hæmoglobin —●— and egg albumin —□— without further additions. Method, ref. 2

Table 1. Reversible Activation and Inhibition of Hurain Action by Fe^{2+}, Zn^{2+} and EDTA. Method, Ref. 3

Enzyme (mgm.)	Fe^{2+} (μmoles)	Zn^{2+} (μmoles)	EDTA (μmoles)	Relative activity, $\frac{I_0}{I}$, 280 mμ
1·0	—	—	—	0·267
	1·0	—	10·0	0·678
	1·0	-	10·0	0·237
0·25	—	—	—	0·180
	—	10·0	—	0·044
	—	10·0	10·0	0·108
0·50	10·0	—	—	0·720
	10·0	10·0	—	0·573
	10·0	20·0	—	0·351

benzoyl-L-arginine-methylester, and the velocity of hydrolysis is increased by the addition of Fe^{2+} (Fig. 2). It appears that hurain does not act on the corresponding amide. The effect of bivalent iron appears to be specific, since Ca^{2+}, Mg^{2+}, Mn^{2+} and Fe^{3+} had no influence on hurain activity; Zn^{2+}, Cd^{2+} and Ni^{2+} inhibit the enzyme action. The mechanism of activation by bivalent iron is not produced by reduction of S–S to SH-groups of the protein. Hurain is not affected by cysteine or other reducing agents[7], and *p*-chloromercuribenzoate.

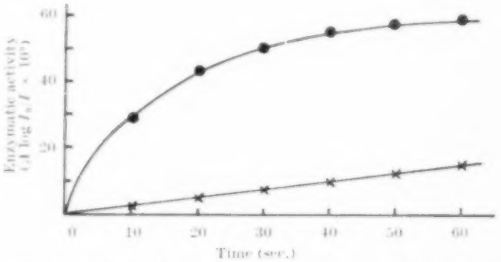

Fig. 2. Activity of crude hurain on benzoyl-L-arginine-methylester without — x — and with —●— addition of Fe^{2+}. Method, ref. 4

Apparently, active hurain represents a reversibly dissociating iron complex, in which Fe^{2+} can be displaced by inhibiting ions as Zn^{2+} or by complexing agents such as ethylenediamine tetraacetic acid (EDTA) (Table 1). The bivalent iron is firmly bound by the protein moiety, at least more firmly than the inhibiting ions. An excess of Zn^{2+} is required to displace the iron from its site of binding. Other evidence for the strong binding of Fe^{2+} is shown by the fact that after 48 hr. of dialysis against EDTA the preparation has 2·2 mgm. per cent iron, that is, about 10 per cent of its original iron content (23·5 mgm. per cent), calculated for dry weight. The amount of iron present in the preparation after dialysis of the crude extract is sufficient to activate partly the hurain.

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Terminology of Protein Structure

I WISH to suggest a revision in the practice of discussing proteins in terms of primary, secondary, and tertiary structures. This terminology, introduced by Linderstrøm-Lang in his Lane Memorial Lectures[1], served well in the few years since it was invented, and has thoroughly permeated the literature. Developments since that time have lessened its usefulness. Arguments to demonstrate this, and suggestions for a more useful general terminology, are the substance of this communication.

One difficulty connected with the terminology is that there is major and widespread disagreement on definitions. For example, in refs. 2–4 disulphide bridges are called primary structures, while in refs. 5–7 they are known as tertiary. Disagreement can also be anticipated with other covalent chain-branches and cross-links. Further, there is confusion about secondary structures: some writers accept only helices as secondary structures[5,7,8], others go a step further and include pleated-sheet models[2,4] and some few[3] maintain that a peptide chain segment or loop may have a meaningful non-random structure in the absence of peptide hydrogen bonding; for example, for steric reasons. Furthermore, it is not generally agreed whether tertiary structure is to mean "the way in which primary and secondary structures are packed together in the molecule"[2] and the resultant molecular shape[2,5,7,8]; or whether tertiary structure should direct attention to the multiple forces maintaining the particular folding of α-helices or other chain conformations in a protein[3,9].

The designations, primary, secondary, and tertiary, tend to connote relative importance which can be misleading. I do not disagree with the primacy of covalent bonds in proteins, but there is no compelling evidence that peptide hydrogen bonds contribute more strongly than side-chain interactions to conformational stability; in fact, there are numerous suggestions to the contrary[2,3,8,10].

Finally, there is a sequential connotation in the primary, secondary, tertiary terminology. While present hypotheses of protein biosynthesis support the notion that formation of peptide bonds in an ordered sequence precedes the change to the three-dimensional structure of the protein, there is little knowledge of processes involved in this transformation. The same issue arises in the reversible denaturation of proteins. It is uncertain whether side-chain interactions lead or follow formation of peptide hydrogen-bonds, or whether, as is my view, there may be an advantage in considering the transformation to be a concerted, co-operative process.

To summarize, considerable ambiguity exists at present in the application of the primary, secondary, tertiary terminology. Further objections to this terminology are that it tends to connote relative importance and a sequence of formation of structural elements. Although it is conceivable that general agreement on definitions might be achieved, the other objections remain. I therefore recommend that use of this terminology be discontinued entirely.

In fact, a general move in this direction has already been noted: a recent symposium on protein structure and function[11] ran its full three-day course with scarcely a reference to secondary and tertiary structure. Apparently several other investigators concerned with protein structure have recognized shortcomings in this terminology. If my present arguments do not succeed in persuading writers to abandon the primary, secondary, and tertiary terminology, I hope that it will at least lead some to a greater awareness of its limitations.

I suggest that protein structure can be discussed generally in terms of amino-acid sequences of peptide chains, called chain sequence, and the ways in which peptide chains and side-chains are arranged in space, called chain conformations. (It has already been noted[12] that configuration has often been used synonymously with conformation. This is undesirable, since configuration traditionally has applied to optically asymmetric centres, and should be reserved for this use. We should speak of the configuration of an amino-acid residue, and of the conformation of a peptide chain.) It appears desirable to subdivide the latter term into side-chain conformations and peptide chain or backbone conformations, without implying that these two subdivisions are mutually exclusive, and certainly without implying rank or sequence of development. Taken together, chain sequences and chain conformations are sufficient to define a structure, which is the three-dimensional location of all the atoms and covalent bonds of a molecule. The factors determining a structure, such as covalent bond lengths and angles, rotational barriers, steric repulsions, hydrogen bonds, electrostatic forces, 'hydrophobic bonds', etc., should not be confused with the structure itself. No general designation seems necessary for the arrangements of protein sub-units into aggregate molecules, as in insulin, haemoglobin, collagen, the caseins, etc. However, if such a term must be employed, 'sub-unit array' seems preferable to 'quaternary structure'[13].

Finally, I wish to emphasize that I have intended criticism only for general ways of discussing protein structure: no criticism is meant for terms describing specific structural elements, such as α-helices, pleated-sheets, polyglycine II type structures and constrained non-hydrogen-bonded backbone loops.

Since there is nothing intrinsically proteinaceous in the designations 'chain sequence' and 'chain conformation' (main and side-chain), these terms may be applicable in structural discussions of chain polymers in general.

I am grateful for discussions of this matter with Dr. E. R. Blout, Prof. L. C. Craig, Prof. J. T. Edsall and Prof. D. Waugh.

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PHYSIOLOGY

Korotkov's Sounds : a Function of the Skeleton to Transmit 'Pulsactor' Signals

Work upon Korotkov's sounds led me[1] to the conclusion that the arterial system could be regarded as an energy transmission line, into which the heart launches energy at two levels, namely, waves with a frequency of 3–15 c.p.s. and waves with a frequency of 256–512 c.p.s. The theory required that the sound waves, resulting from forces of cavitation, be transmitted throughout the arteries, with a velocity much higher than that of the waves of low frequency, to explain the development of arterial stationary waves.

Sound waves are indeed transmitted by arteries, Kerr and Harp[2] giving velocities of the order of that of the pulse-wave, 4–5 m./sec. Comparable results are found in fluid-filled elastic tubes where, however, should the wave arise from a unit impulse function, longitudinal waves may occur, transmitted with a velocity of 30 m./sec., as reported by Citters[3]. Landowne[4], moreover, has shown that externally produced impact waves are propagated along living arteries with an average velocity of 17·1 m./sec. These velocities, however, are not sufficiently high for the theory, and, certainly on transmission in fluid-filled elastic tubes, sound waves, especially of higher frequencies, undergo rapid attenuation.

Now bone is an excellent conductor of sound, the velocity of transmission is about 3,900 m./sec. and bone conduction of the heart sounds occurs *in vivo* : Turrettini[5], for example, observed that the murmur of mitral regurgitation was audible over the sacrum. McKusick[6] describes conduction of heart sounds, via the ribs rather than directly through the chest, as "circumferential transmission", when auscultation is performed over the back.

In aortic stenosis, loud systolic murmurs may be heard with the aid of a stethoscope, or microphone, applied to the olecranon : it was discovered by Levine and Likoff[7] that this sound is unaffected by occlusion of the brachial artery with a pressure cuff, so proving that the sound is conducted by bone. These workers also reported a case where a diastolic murmur, due to syphilitic aortic incompetence, was audible on auscultation over the skull.

The above observations support the following amendment to the original theory :

The sternum acts as a sounding board that resonates to the heart sounds, the body of the sternum being more favourably placed to resonate to the first sound ; the manubrium to the second. The clavicle conducts the sounds to the scapula by which they are transmitted to the bones of the arm. The ribs conduct the sounds to the vertebral column by which they are conducted upwards to the skull, which acts as a cavity resonator, and downwards to the sacrum and so to each hip bone by which they are transmitted to the bones of the leg.

Conduction at joints is by the ligaments, which are so attached that they act as matching devices. In the case of the costal cartilages, the sound may be conducted by the perichondrium. The clicking nature of the noises arising in joints suggests that sound waves of frequencies up to, say, 10,000 c.p.s. are involved : frequencies even higher should be considered.

What function could such a phenomenon subserve ? Probably the following : the skeleton acts as an aerial, broadcasting the heart sounds throughout the body, the sound being conducted, finally, from bone to soft tissue by fibrous, ligamentous and muscular attachments. Each sound acts as a signal, imparting a slight jolt to the branches of the vascular system, analogous to the effect of pulsactor circuits employed in radar and utilized to overcome initial and terminal high impedance of other circuits in which momentary flow of current is required.

A similar concept was introduced by me[8] in connexion with blood flow in the coronary arteries, applying the term 'to overcome thyxotropism'. Since the transmitted sound waves are likely to have the further effect of synchronizing pulsation of the peripheral arteries, they may be described as 'pulsactor signals'. In turn, the action of the heart, initiating these, may be termed that of a 'synchronizing signal generator'.

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An Effect of Glucose on Acetate Metabolism in Sheep

Ruminants derive their energy requirements essentially from lower fatty acids (acetic, propionic and butyric) and thus differ from non-ruminating animals. The concentration of glucose in the blood of sheep, which is extraordinarily low when compared with that of non-ruminants, is probably an expression of the sparsity of the exogenous glucose available in the metabolism of these animals[1,2].

It is unlikely, however, that glucose plays no important part in the metabolic pathways in the sheep. Certainly glucose has an important role[3] in the young lamb. In adult sheep glucose, though in limited supply, might well be implicated in aiding the metabolism and utilization of acetate by the tissues. It is the purpose of this communication to examine this hypothesis.

In this work estimations of the rate of disappearance of acetate after intravenous injection were used as a measure of the sheep's ability to 'utilize' acetate.

Six well-trained Merino wethers, aged 2 years, were fed in pens for 6–8 weeks on 800 gm. of chaffed wheaten hay plus 7 mgm. cobalt chloride once a week to ensure adequate vitamin B_{12} status. Four of the six animals were used in the experiments without change of diet, while two were given, 2 days before the observations were made, a ration of 500 gm. of chaffed wheaten hay plus 300 gm. of chaffed lucerne hay.

Estimations on the rate of disappearance of acetate from the blood were made by determinations of the concentration of volatile fatty acids in the blood at 30, 60 and 90 min. after an injection of 5 m*M*/kgm. of acetic acid neutralized to *p*H 7·0 with caustic soda and diluted to 75 ml. with distilled water. The injection was made through a polythene tube inserted

and fixed into the jugular vein and usually was completed within 3–5 min.

A few days following the determination of the rate of disappearance of the acetate by this means an injection of glucose (1·0 gm./kgm.) was given, followed half an hour later by an injection of acetate, and the rate of disappearance of acetate was then again determined. The injection of glucose resulted in a profound hyperglycæmia, the blood sugar-level being elevated throughout the experimental period by at least 100 mgm./100 ml. blood over the normal control-levels. After 2–3 days had elapsed control observations (without glucose injections) were again made. The results are presented in Table 1.

Table 1. Concentration of Volatile Fatty Acids in Blood (mM/l.) after the Injection of Acetate (5 mM/kgm.)

Minutes after acetate injection	Wheaten hay chaff (mean of 4 animals ± S.E.)		Wheaten hay chaff + lucerne chaff. Data from 2 animals			
	Acetate only	Glucose then acetate	Acetate only	Acetate only	Glucose then acetate	Acetate only
0	0·38 ± 0·13	0·50 ± 0·11	0·51 ± 0·08	0·45 0·35	0·53 0·51	0·32 0·70
30	7·24 ± 0·11	6·02 ± 0·26	6·99 ± 0·24	5·65 6·30	4·28 4·91	6·25 5·96
60	3·46 ± 0·10	1·54 ± 0·16	3·27 ± 0·34	2·03 1·06	0·73 0·62	1·96 1·88
90	1·77 ± 0·19	1·29 ± 0·11	1·49 ± 0·17	0·95 1·07	0·58 0·60	0·87 0·80

It is apparent from Table 1 that prior administration of glucose led to a more rapid rate of removal of acetate from the blood than occurred in control experiments in which no exogenous glucose was given. The results emphasize the importance of diet in this respect, for the incorporation of lucerne chaff in the diet, although only for so short a period as 2–3 days before the experimental observations, significantly changed the rate of 'utilization' of acetate. The importance of the nature of the diet has previously been stressed[4,5]. It might thus be considered that an interrelationship exists, not between acetate and glucose itself but between acetate and the glucose precursor, propionate. When the rations are comprised largely of crushed maize an enhanced production of propionate results, and, then after being introduced intravenously, both glucose and acetate disappear from the blood more rapidly than from the blood of control animals on standard diets[4]. Recent work[3], however, does not favour the direct implication of propionate, and from the work reported here, it is suggested that glucose, as in non-ruminants[6], may be important in aiding in the 'utilization' of acetate which is so essential to the metabolism of the sheep.

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Evidence of Secretion of an Aldosterone-stimulating Substance by the Kidney

Hæmorrhage causes a two-fold increase in aldosterone secretion in hypophysectomized dogs[1]. We have found recently that nephrectomized hypophysectomized dogs fail to show this rise, and that saline extracts of dog kidney contain an aldosterone-stimulating substance.

Ten male mongrel dogs (average weight, 12·1 kgm.) were subjected to left nephrectomy. Five or more days later, the dogs were anæsthetized with pentobarbital and the right kidney removed (5 dogs), or an adjustable ligature placed around the renal artery and vein (5 dogs). The right lumbo-adrenal vein of each dog was then cannulated and the animals hypophysectomized via the transbuccal route. One hour later, a control adrenal venous blood sample was collected from each of the five dogs with a ligature around the vessels of the remaining kidney. The ligature was tightened and two more adrenal vein samples were collected at 20-min. intervals. In the dogs in which the remaining kidney had been removed, two specimens of adrenal venous blood were collected starting 1 hr. after hypophysectomy. All dogs were then bled by removing 15 ml./kgm. body-weight of femoral arterial blood over a 6-min. period. Adrenal venous blood samples were collected 10, 40 and 70 min. after the start of hæmorrhage. In five instances, the experiment was continued by re-infusing the shed blood over a 6-min. period and collecting adrenal venous blood 10 and 30 min. thereafter. Four of these dogs were given 1 i.u. of adrenocorticotrophic hormone intravenously and an adrenal vein sample collected starting 5 min. after the injection. Ten similarly studied hypophysectomized dogs with intact kidneys (average weight, 12·9 kgm.) served as controls.

Extracts of tissues were made by dicing normal dog kidney or spleen, mixing the tissue with 50 or 100 ml. of isotonic saline, straining through cheesecloth, and centrifuging at approximately 3,000 r.p.m. for 15 min. The supernatant was injected intravenously over a 1-min. period into hypophysectomized–nephrectomized dogs and adrenal venous blood was collected starting 5 min. after each injection. The dose of extract used in each case was equivalent to 1 kidney or ½ spleen. Control injections of an equal volume of isotonic saline were performed in 3 dogs. All hypophysectomies were found to be complete by gross examination at autopsy. Blood pressure was monitored continuously, using a Statham strain gauge manometer and Grass model 4 polygraph. The adrenal venous blood samples were centrifuged promptly, and the plasma frozen for subsequent analysis of aldosterone content by the double isotope derivative method[2] and 17-hydroxycorticoid content by the method of Silber and Porter[3].

The results are summarized in Tables 1 and 2. There was a slight, but statistically significant, fall in aldosterone secretion following ligation of the renal vessels, and the control values in the nephrectomized–hypophysectomized dogs were significantly lower than those of the hypophysectomized dogs. Following hæmorrhage, aldosterone secretion-rates rose at least 5 mμgm./min. in all 10 hypophysectomized dogs, while no rise occurred in 8 out of 10 nephrectomized–hypophysectomized dogs. The mean values for aldosterone secretion after hæmorrhage were significantly higher in the dogs with intact kidneys. Adrenal responsiveness to adrenocorticotrophic hormone was

Table 1. Changes in Aldosterone Secretion-rate following Haemorrhage

Values are means ± S.E.; figures in parentheses are number of dogs for each value

	Aldosterone secretion-rate (μgm./min.)	
	Hypophysectomized dogs	Nephrectomized Hypophysectomized dogs
Before ligating renal vessels	—	7·4 ± 0·8 (5)
Control 1	10·6 ± 3·6 (10)	2·8 ± 0·8 (10)
Control 2	9·2 ± 3·4 (10)	4·0 ± 0·7 (10)
10 min. after haemorrhage	18·8 ± 4·2 (10)	6·7 ± 3·3 (10)
40 min. after haemorrhage	—	4·1 ± 1·7 (10)
70 min. after haemorrhage	15·3 ± 3·5 (10)	4·2 ± 1·5 (10)
10 min. after re-infusion	13·7 ± 4·2 (10)	5·2 ± 0·8 (5)
30 min. after re-infusion	18·3 ± 3·0 (10)	4·4 ± 0·7 (5)
After ACTH (1 I.U. intravenously)	59·8 ± 9·7 (8)	68·8 ± 10 (4)

Table 2. Changes (mean ± S.E.) in Adrenal Secretion and Blood Pressure after Injection of Kidney and Spleen Extracts and Saline

The aldosterone and 17-hydroxycorticoid values are the difference between the rate following injection and the control value immediately before injection. Blood pressure values represent the maximum value after injection minus the value before injection

	Kidney extracts (9 exp.)	Saline (3 exp.)	Spleen extracts (2 exp.)
Mean change in aldosterone secretion-rate (mμgm./min.)	+26·7 ± 7·2	+1·7 ± 2·4	−5·8
Mean change in 17-hydroxycorticoid secretion-rate (μgm./min.)	+2·0 ± 0·6	+0·1 ± 0·1	−0·4
Mean change in systolic blood pressure (mm. mercury)	+72·8 ± 10·8	+16·7 ± 8·8	−2·5
Mean change in diastolic blood pressure (mm. mercury)	+66·7 ± 7·4	+11·7 ± 7·3	+2·5

retained in the dogs without kidneys, as indicated by the slightly greater response to adrenocorticotrophic hormone in this group. Except after adrenocorticotrophic hormone injection, 17-hydroxycorticoid secretion was less than 3 μgm./min. in all dogs and was unaffected by haemorrhage and retransfusion. After adrenocorticotrophic hormone, 17-hydroxycorticoid values were 8·1 ± 1·1 μgm./min. (mean ± S.E.) in the nephrectomized dogs and 5·9 ± 0·9 μgm./min. in the controls.

Injection of the saline extract of 1 normal dog kidney caused a large rise in aldosterone secretion in 8 out of 9 instances (Table 2), with a mean increase of 26·7 mμgm./min. 17-hydroxycorticoid values also increased slightly. Systolic and diastolic blood pressure rose markedly. Control injections of equal volumes of saline had no effect on the secretion of either hormone, although they did cause a 10–15 mm. mercury rise in blood pressure. Spleen extracts (2 dogs) had no effect on adrenal secretion or blood pressure.

Similar experiments have been carried out independently by Davis *et al.*[4], and similar results obtained. The fact that aldosterone secretion rises after haemorrhage in hypophysectomized dogs indicates that some non-pituitary factor is involved. A renal source for this factor is suggested by the absence of the response in nephrectomized animals and the presence of an aldosterone-stimulating substance in kidney extracts.

The nature of this aldosterone-stimulating substance is uncertain. Richards and Sayers[5] found that extracts of normal rat kidneys caused adrenal ascorbic acid depletion in hypophysectomized rats and assumed that the material giving the response was adrenocorticotrophic hormone. A slight rise in 17-hydroxycorticoid secretion followed the injection of extracts of normal kidneys in the present experiments, and it is possible that adrenocorticotrophic hormone extracted from the kidneys was responsible for the observed effects on aldosterone secretion. However, doses of commercial adrenocorticotrophic hormone which produce 17-hydroxycorticoid responses of this magnitude have no effect on aldosterone secretion in the hypophysectomized dog[4].

In 1951 Deane and Masson[6] reported that renin injections led to hypertrophy of the zona glomerulosa of the adrenal. Recently, Genest *et al.*[7] and Laragh *et al.*[8] have reported that injection of synthetic angiotensin into normal humans caused an increase in aldosterone secretion. Preliminary experiments by us indicate that synthetic angiotensin increases adrenal secretion of aldosterone and 17-hydroxycorticoids when injected into hypophysectomized–nephrectomized dogs in very small doses. Since haemorrhage causes an increased secretion of renin[9], the present results are consistent with the hypothesis that the renin–angiotensin mechanism is responsible for the increase in aldosterone secretion following haemorrhage in hypophysectomized dogs.

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Isolation and Partial Characterization of a Growth-control Factor

A growth-promoting factor in liver extracts has been reported in work on a chemically defined medium for the axenic cultivation of the nematode, *Caenorhabditis briggsae*[1]. An active fraction has now been isolated from horse liver by salt precipitation and column chromatography. The purified material emerged from the column as a discrete protein peak. By electrophoretic analysis (through the courtesy of Dr. Arthur Karler, Karler Laboratories, Berkeley, California) on cellulose acetate strips and ultracentrifugal analysis (through the courtesy of Dr. F.

Lindgren, Donner Laboratory, University of California, Berkeley), it appeared to be essentially a single component. Twelve amino-acids have been demonstrated in a hydrolysate of the active fraction.

Freshly excised liver was cut into small pieces and autolysed for 24 hr. at 4° C. All subsequent procedures were carried out in the cold. A 1 : 1 homogenate was made in water, and after centrifugation the residue was discarded. Ammonium sulphate was added to the supernatant fluid to obtain the material which precipitated between 40 and 60 per cent saturation at *p*H 7·0. This precipitate was dissolved in distilled water and reprecipitated with ammonium sulphate between 45 and 60 per cent saturation. After centrifugation, the precipitate was redissolved and dialysed to remove ammonium sulphate. This material was then applied to a column of hydroxylapatite[2] and eluted with successive increases in concentration of phosphate buffers. The eluates contained six discrete protein peaks. These six fractions were sterilized by filtration ('Millipore', size *G.S.*) and assayed with *C. briggsae*. Only one of them was found to be biologically active.

The growth-promoting property of this protein fraction for *C. briggsae* was tested in a chemically defined basal medium[3] which is protein-free. In the basal medium, young larvæ survived but increased in size only to a limited extent. But, in medium to which the fraction had been added, maturation and reproduction occurred. The purified protein material showed the freeze-activation phenomenon described previously[4]. When freeze-activated, 39 μgm. of protein (optical density 280/260) per ml. of culture medium was found to be adequate for maturation and reproduction. A higher level (158 μgm. protein per ml.) was selected for prolonged maintenance, and seven generations were afterwards subcultured. Successive inocula were first-generation larvæ of respective preceding cultures.

None of the other fractions from the column was active in the nematode assay, either before or after freeze-activation treatment.

In other experiments, this fraction was tested as a replacement for the serum requirement of a tissue culture cell line (McCoy, originally obtained through the courtesy of Dr. C. M. Pomerat). Stock cultures of McCoy cells were maintained in a medium composed of mixture 199 (Microbiological Associates), lactalbumen hydrolysate, and calf serum[5]. Cultures were trypsinized, washed, and resuspended in a deficient medium composed of mixture 199 plus antibiotics. Aliquots were dispensed into Leighton tubes and were incubated for 4–6 hr., at which time the rounded cells had become attached to the glass. The medium was decanted and replaced according to the following schedule: series 1—complete serum medium plus adenylic acid; series 2—serum-deficient medium plus adenylic acid; and series 3—serum-deficient medium plus fraction (79 μgm. protein per ml. freeze-activated in adenylic acid) to be assayed. After 18 hr. incubation, the cell sheet of series 1 was confluent and individual cells were like epithelium. Cells in series 2 were enlarged slightly and for the most part were still round, with little evidence of differentiation or multiplication. A small number of these cells showed evidence of fibroblast-like growth. In series 3, most cells had proliferated into fibroblast-forms and some into epithelial-forms. Although the cell sheet did not attain the confluent aspect observed in the serum controls, it far surpassed the growth and differentiation obtained in the deficient medium.

The findings of these experiments suggest that this purified protein fraction may play a general regulatory part in growth and differentiation.

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Œstrogen Protection against Acute Digitalis Toxicity in Dogs

Grimmell and Smith[1] have demonstrated that castrated female dogs prophylactically treated with œstradiol-17β are much more resistant to a toxic intravenous dose of digoxin than are untreated castrated controls.

In an extended search for a medicinal agent which would duplicate the protective effect of the ovarian hormone without œstrogenicity, a large list of steroids fabricated on the naturally occurring œstratriene nucleus have been studied. Among such steroids our best compound so far is 1,3,5(10),16-œstratetraen-3-ol methyl ether. This highly active steroid was prepared both by the methylation of 1,3,5(10),16-œstratetraen-3-ol and by the pyrolysis[2] of the *p*-toluenesulphonate of 3-methoxy-1,3,5(10)-œstratrien-16β-ol[3]. It has a melting point of 68° and an optical rotation of $[\alpha]_D^{24} = +115° \pm 2$ ($c = 0{\cdot}615$ in chloroform). Apparently a crystalline modification melting at 71–72° exists.

After many endocrine studies we do not yet know the physiological mechanism(s) involved in steroidal protection against digitalis toxicity. Adult, female, mongrel dogs weighing 7–14 kgm. were ovariectomized by a technique which included hysterectomy and then permitted a minimal period of 4 weeks for post-operative recovery. The test substance was dissolved in sesame oil and administered intramuscularly at a dose-level of 0·5 mgm./kgm. daily for 7 days, with vaginal smears being taken prior to and at intervals during the administration. Food was withheld from all animals for a period of 18–24 hr. before the acute experiment, but water was allowed *ad libitum*. On the eighth day of the experiment anæsthesia with pentobarbital sodium (30 mgm./kgm.) was induced and a cathode-ray electrocardiograph was installed for continuous observation of the electrocardiogram, lead aV_F being used regularly. Permanent tracings of this lead were made at frequent intervals with a Sanborn twin-viso electrocardiograph. After a 30-min. control period during which the normal electrocardiographic pattern was recorded, digoxin (0·15 mgm./kgm.) was administered intravenously. The electrocardiogram was observed continuously and the time of appearance of the arrhythmia was recorded (the term 'arrhythmia' refers to a complete atrioventricular block with idioventricular tachycardia).

Table 1

Steroid used in prophylactic treatment	Time of onset of arrhythmia (min.)	State of oestrus
1,3,5(10),16-oestratetraen-3-ol methyl ether	>60	Anoestrus
	>60	"
	38	"
	>60	"
	30	"
None	21	Anoestrus
	19	"
	24 (av. 20)	"
	18	"
	18	"

If this arrhythmia did not occur within a time-limit of 60 min., protection against the digoxin intoxication was arbitrarily considered to be 100 per cent, as survival has always been indefinite with this degree of protection.

In Table 1 are recorded the results with 5 castrated female dogs prophylactically given 1,3,5,(10),16-oestratetraen-3-ol methyl ether against the results with 5 similar animals untreated. Not only was this steroid non-oestrogenic in our experiments, but it also demonstrated a markedly superior protective action. Curiously, the free phenol—1,3,5(10),16-oestratetraen-3-ol[4]—is not as potent as its 3-methyl ether; and the free phenol, furthermore, produces oestrus in our routine experiments.

We have never observed augmentation of digoxin toxicity by an oestrogen or oestrogen-like steroid. Such steroids, if protectively inactive, demonstrate onset of arrhythmia at time-intervals identical to those of controls within experimental error.

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Hyaluronic Acid in the Uterine Wall of the Guinea Pig during the Sexual Cycle

The amount and function of acid mucopolysaccharides in the mammalian uterus are not yet known. A metachromatic staining material has been described in the endometrial stroma of the human uterus[1-3] during the proliferative phase of the sexual cycle, and recently the presence of a periodic acid–Schiff positive material in the uterus of swine during the sexual cycle has been established[3]. Nothing definite has been found in the literature concerning the possible importance of hyaluronic acid in the physiology and pathology of the uterus. Investigations concerning the acid mucopolysaccharides of the uterus have been undertaken, since alteration in the quantity or quality of the ground substance may prove to be important in the pathogenesis of uterine infections and possibly in other disorders.

Forty mixed coloured virgin female guinea pigs, 3–5 months of age, were used in this investigation. They were kept at a relatively constant temperature, between 68° and 72° F., and fed with a standard ration; fresh water was given *ad libitum*. The sexual cycle was followed by daily examination of vaginal smears, stained by Papanicolaou's method. Using this method, it was possible to kill animals in a given phase of the sexual cycle, that is, pre-oestrus, oestrus, post-oestrus, and di-oestrus. A small block of tissue was removed from each uterus approximately 1 cm. distal to the bifurcation, and this was fixed in 10 per cent formol-alcohol. The remainder of the uterus was put in acetone immediately, and stored at −20° C. for future chemical examination. Paraffin sections were prepared from the block of tissue and stained as follows: Hale colloidal iron method for mucopolysaccharides as modified by Rinehart and Abul-Haj[5]; period acid–Schiff method of McManus; and 0·5 per cent aqueous toluidine blue.

Hyaluronic acid was extracted from the remainder of the uterus by the method described by Hayashi *et al.*[6], with the slight modification that an additional filtration was done at the end of the dialysis procedure. The extract, proved to be free of protein and sulphur, was dissolved in 1·2 ml. of 0·1 *M* veronal-acetate buffer at *p*H 6. One drop of the solution of each extract was spread over an area 0·5 cm. in diameter on a glass slide. The dried smears were then stained with toluidine blue[6], at *p*H 6·9; 4·1; 2·5 and 1·0. Some of the dried smears were treated with hyaluronidase for 1, 2 and 3 hr. at 37° C. before staining, using a concentration of 100 VR units per ml. The enzyme was dissolved in 0·1 *M* acetic buffer *p*H 4·7, containing 0·15 *M* sodium chloride. Controls were incubated at the same time with the buffer solution only. Dried smears of chemically pure hyaluronic acid, chondroitin sulphate and heparin were also used as controls.

The smears of the uterine extracts showed a significant metachromasia at *p*H 6·9 and 4·1 with diminished metachromasia at *p*H 2·5 and none at *p*H 1·0. Treatment of the smears with the hyaluronidase for 60–90 min. caused a complete loss of metachromasia. The smears of known chondroitin sulphate and heparin showed distinct metachromasia in all ranges of *p*H tested, including *p*H 1·0, while the known smear of hyaluronic acid gave results similar to the experimental extracts of the uterus. Hayashi *et al.*[6] reported that metachromatic staining with toluidine blue at *p*H 1·0 is highly specific in differentiating non-sulphate acid mucopolysaccharides from the sulphated form. On this basis, our results suggest that the acid mucopolysaccharide from the uterus is hyaluronic acid. An attempt was made to extract chondroitin sulphate from the uteri of other guinea pigs, using the method described by Hayashi[6], with negative results.

Histochemical examination of the uterine sections showed the presence of an acid mucopolysaccharide which was distinctly blue (with the Hale method of staining) and metachromatic with toluidine blue, but only slightly positive with the periodic acid–Schiff method. This material was seen in both the endometrial epithelium and stroma. The histochemical observations varied during the different phases of the sexual cycle. In particular, the amounts of demonstrable acid mucopolysaccharide were notably increased during oestrus and, at this time, the periodic acid–Schiff staining reaction became more strongly positive.

The results reported suggest that hyaluronic acid is the major mucopolysaccharide in the uterine wall of the guinea pig, and that either the amount or quality of this ground substance material varies with the phase of the sexual cycle, being maximal, as judged by histochemical methods, during oestrus. Quantitative and qualitative investigations are now being completed on the uterine extract and will be published.

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Electrical Excitability of Isolated Frog Skin

In the course of investigating the electrical properties of frog skin with short current pulses, it was discovered that this preparation is capable of exhibiting electrical excitability. The present communication is concerned with a description of this phenomenon.

The abdominal skin of the frog *Rana pipiens* was removed and immediately mounted between two cylindrical 'Lucite' compartments, 6·5 cm. long, 1·15 cm.^{2} cross-sectional area. There were holes at the far end of each compartment for the silver/silver chloride stimulating electrodes, and at each end adjacent to the skin was a small hole for the bridges (polyethylene tubes containing saturated potassium chloride in agar solution) going to the recording calomel electrodes. Each compartment was filled with Gray–Ringer solution (71·75 m*M* NaCl; 5·00 m*M* KCl; 2·50 m*M* $CaCl_2$; 1·60 m*M* $MgCl_2$; 20·00 m*M* $NaHCO_3$; 1·03 m*M* Na_2HPO_4; 0·12 m*M* NaH_2PO_4; 0·26 m*M* glucose. Solution is saturated with a 97 per cent O_2, 3 per cent CO_2 gas mixture), and within 1 hr. a steady state value of the resting potential across the skin obtained (25–60 mV., inside surface positive). Current through the skin and voltage across it were recorded on a Tektronix 502 dual beam oscilloscope (input impedance 10 MΩ); the square waves of current were obtained from an AEL laboratory stimulator through a 100 kΩ series resistance.

Fig. 1 shows a typical set of responses of the skin to square waves of current of 35 m.sec. duration. At low values of inward (depolarizing) and outward (hyperpolarizing) current (by an inward current is meant a current produced with the cathode in the solution bathing the inner surface of the skin and the anode in the solution bathing the outer surface; the reverse is the case for an outward current) (Fig. 1*a*) the voltage responses are almost symmetrical and phenomenologically identical to the behaviour of a network consisting of a resistance and capacitance in parallel (RC network). The observed resistance was from 0·5–1·0 kΩ/cm.^{2}; capacitance from 2–5 μF/cm.^{2}. As the magnitude of the current pulse is increased, the potential changes begin to show non-linearity and rectification (Fig. 1*b*). At still higher current density the system is very non-linear, and for an outward current pulse, overshoot occurs (Fig. 1*c*). As the magnitude of the current pulse is continually increased, a value is eventually reached at which the skin is near threshold. At this point, if the magnitude of the current pulse is increased slightly, the skin responds with an action potential for inward current pulses, while continuing to give an overshoot for outward currents (Fig. 1*d*). (The overshoot response for outward current pulses as seen in Fig. 1*c* seems to be a 'poor' action potential, for in some skins an action potential with a sharp threshold and a form essentially the mirror image of the type shown in Fig. 1*d* occurs.)

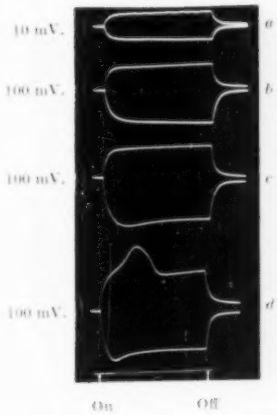

Fig. 1. The change in potential across isolated frog skin produced by 35-m.sec. square waves of current. Upward response is result of inward current; downward response is result of outward current. Currents are 20 μamp., 210 μamp., 500 μamp. and 550 μamp. for *a*, *b*, *c* and *d* respectively. Resting potential is 30 mV., inside positive. Gray–Ringer solution on both sides

Following an action potential, the skin becomes refractory for several seconds, not exhibiting an active response to the same stimulus that previously elicited it. If during this period the skin is stimulated at the rate of 10/sec. or faster, it will continue to remain refractory and show only an RC-type of response; stimulation at the rate of 1/sec. or less, on the other hand, has no appreciable effect on the duration of the refractory period.

In Fig. 2 is seen a striking example of the recovery of excitability following a full response. In this experiment a small short (2·5 m.sec.) pulse was superimposed on a 40 m.sec., just sub-threshold pulse. The interval between successive records was three seconds. Curves *a*, *b*, and *c* show a characteristic sub-threshold 'local response'; curve *d* is the full action potential. A pulse 3 sec. after this would give curve *a* again, etc.

I wish to point out several important features of these action potentials: (1) the response is large, in some skins being as great as 300 mV. (by the magnitude of the response I mean the difference between the peak height and the maximum sub-threshold level); (2) the long refractory period, which is of several seconds duration; (3) the sharp threshold, which is a general characteristic of more familiar excitable systems. Finally, I wish to contrast this response of frog skin to the changes of potential observed on stimulation of the nerves to the skin[1].

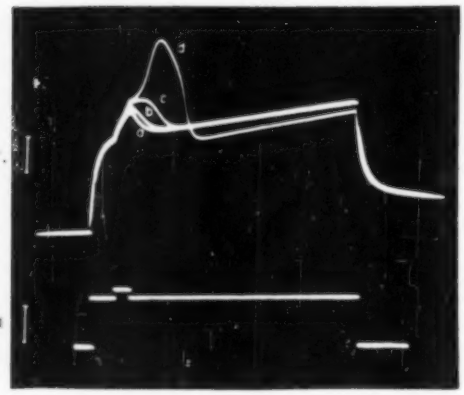

Fig. 2. The change in potential across isolated frog skin produced by a 40-m.sec. just sub-threshold inward square wave of current with a superimposed 2·5-m.sec. small inward square wave. Successive responses *a*, *b*, *c* and *d* are 3 sec. apart. Resting potential is 60 mV., inside positive. Gray–Ringer solution on both sides

I have repeated some of this earlier work and have confirmed that the response in this case is very slow, being of several seconds duration and quite different from the observations described. Other workers have attributed these slow changes to the skin glands.

With regard to the site in the skin of the electrical activity, it seems fairly clear that the magnitude of the effect and particularly the dependence of the direction of the response on the polarity of the stimulus precludes consideration of all unoriented structures, that is, smooth muscle and nerve twigs. This leaves us only with the epithelial cells and the glands. It is interesting that we have found that the toad bladder, the electrical and permeability properties of which are known to be in many ways quite similar to those of frog skin, exhibits essentially the same electrical excitability as described for the skin. In the bladder, the epithelial layer consists of a single sheet of cells with no glands. (About 5 per cent of these cells secrete mucus (Peachey, L. D., personal communication).) It seems, therefore, that the action potentials evoked in frog skin and toad bladder come from the germinal layer of epithelial cells. It is to these cells that is generally attributed the resting potential and 'transport properties' of these organs. A more detailed report on the phenomenon discussed here will appear elsewhere.

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HÆMATOLOGY

Erythrocyte Glucose-6-Phosphate Dehydrogenase Deficiency in New Guinea and New Britain

Comparative investigations carried out on erythrocyte glucose-6-phosphate dehydrogenase deficiency in Negro and Caucasian subjects have revealed quantitative differences between these two groups[1]. It is suggested that different genetic mechanisms account for the deficiency of glucose-6-phosphate dehydrogenase in Negroes and Caucasians. This led to a search for other populations which might exhibit the trait, and which might therefore help to elucidate some of the questions concerning gene action in man.

Employing the rapid screening test described by Motulsky[2] a survey has been carried out on 155 subjects in the Gazelle Peninsula, New Britain, and 534 subjects in the Eastern Highlands, New Guinea. Any samples showing significant haemolysis in the supernatant sera were discarded. Red cells from blood clots, both in field samples and in laboratory controls stored under conditions identical to those of transportation, have proved to be as satisfactory as those from similarly treated heparinized blood samples, provided the haemoglobin value in all cases is adjusted to a constant standard value. Further controls were used in the form of repeated blood samples from a single normal European in New Guinea. The results are shown in Table 1.

Table 1

Area	Sex	No. examined	No. deficient
New Britain (Gazelle Peninsula)	Male	94	16
	Female	61	0
	Total	155	16
New Guinea (Eastern Highlands)	Male	383	3
	Female	151	0
	Total	534	3

Several females in the New Britain series had enzyme-levels in an intermediate range, possibly indicative of a heterozygous situation. For the first time the trait has been found to exist in New Guinea and New Britain, but with greatly differing incidence, 0·56 and 10·3 per cent, respectively, in these two areas. The Gazelle Peninsula in New Britain is highly malarious, while the several groups tested from the Eastern Highlands of New Guinea inhabit low- or non-malarial areas. These results thus add evidence supporting Motulsky's contention[2,3] that there may be a selective advantage in the development of this trait, in that enzyme-deficient persons may be more resistant to falciparum malaria. Populations previously reported to have a high incidence of glucose-6-phosphate dehydrogenase deficiency also exhibit the sickle-cell trait, but sickle-cell haemoglobin has not been found in New Guinea[4] or New Britain[5]. In 13 of the 19 deficient cases reported here, there was no apparent segregation according to haptoglobin type, although the series is as yet too small for definite conclusions.

No cases of primaquine sensitivity have yet been reported in New Guinea (Schofield, F. D., personal communication). However, primaquine is given only to highland peoples when they return from the coast to their own malaria-free or comparatively non-malarious home areas. It is not used in treating native people in coastal regions, as the chances of re-infection with malaria are so high.

The finding of another distinct population with deficiency of erythrocyte glucose-6-phosphate dehydrogenase, as revealed by this preliminary survey, provides material for further evaluation of the gene-enzyme interaction concerned. Further investigations are in progress to determine more precisely the relation between malarial distribution and incidence of the trait, and to examine possible protection of the enzyme deficiency against malarial infection. A study is also being made of factors such as heat

lability, *p*H optimum, and of the effect of storage on the enzyme in deficient subjects, for comparison with those of the enzyme in affected Negroes and Caucasians.

Acknowledgment is made of the co-operation of Dr. D. C. Gajdusek, of the National Institutes of Health, Bethesda, Maryland, and Mr. R. T. Simmons, of the Commonwealth Serum Laboratories, Melbourne, in obtaining blood samples, and of Dr. C. Curtain, of the Baker Institute, for the haptoglobin investigations.

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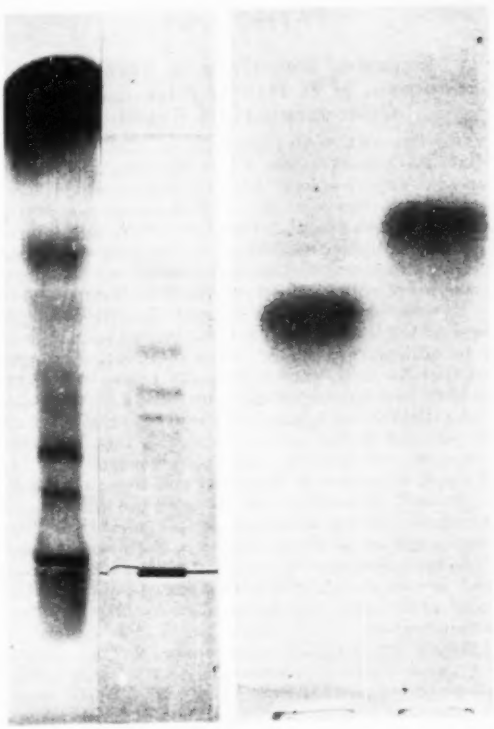
Isolation of Haptoglobin by Chromatography on Diethylaminoethyl-Cellulose (DEAE)

HAPTOGLOBIN was isolated first by Jayle *et al.*[1] using a technique which combined precipitation by ammonium sulphate with preparative starch-gel electrophoresis. More recently we found that haptoglobin could be obtained as a by-product during the routine fractionation of human plasma[2,3]. This technique uses rivanol as a precipitating agent for the subfractionation of fraction IV, obtained at *p*H 5·8, and 35 per cent alcohol concentration, the final purification being achieved by chromatography on DEAE.

This technique gives pure haptoglobin suitable for metabolic research studies with and without addition of haemoglobin[4]. However, geneticists interested in the variation of haptoglobin groups often have only small samples of plasma at their disposal and they only need minute amounts of the isolated protein as test substances for electrophoretic work.

In our routine technique, the final purification of haptoglobin is obtained by adsorption of haptoglobin at *p*H 5 on DEAE using 0·03 *M* acetate buffer, whereas siderophilin, the main contaminant, is not adsorbed. Haptoglobin can be adsorbed under the same conditions from whole plasma, but is then accompanied by other proteins: ceruloplasmin, a second α_2-glycoprotein, cholinesterase and some α_1-globulins. Smithies[5] already showed that the selective adsorption of haptoglobin needs a rather low *p*H. However, we noticed that haptoglobin at about 80 per cent purity can be obtained with a slightly modified elution technique.

Plasma is diluted to give a freezing point of 0·15°. The *p*H is then adjusted to 5 with acetic acid 0·03 *M*; DEAE-cellulose is equilibrated against acetate buffer 0·03 *M*, *p*H 5, a minimum of 25 gm. of dry cellulose being necessary for 1 l. of plasma. The adsorbent is poured into a column (the diameter being proportional to the volume handled) and the diluted plasma is passed by gravity flow. The column is then washed with acetate buffer, 0·03 *M*, until no more proteins appear in the effluent. Haptoglobin can then be eluted with 0·1 *M* acetate buffer, *p*H 5.



(*A*) (*B*)

Fig. 1. *A*, Haptoglobin 2 : 1 separated by batch-adsorption from a small plasma sample. Eluate slightly concentrated. *B*, Haptoglobin 1 : 1 with and without added haemoglobin. Sample obtained by column chromatography of 250 ml. of plasma

The solution should contain 2–4 gm./l. of proteins; the total yield of haptoglobin based on the haemoglobin-binding capacity is about 50–60 per cent.

Ceruloplasmin together with some α_1-globulin can be eluted at 0·2 *M* acetate buffer concentration and at the same *p*H. A second, not yet identified, α_2-glycoprotein is eluted at 0·5 *M* acetate buffer.

Satisfying results have been obtained with small samples (2–4 ml.) as well as with volumes of 1 l. of plasma and more. Batch-adsorption can be used instead of the column adsorption. Since no dialysis is necessary, it is possible to achieve the isolation of haptoglobin a few hours after the collection of the blood sample.

The purity and the yield of the separated product seems to give data corresponding to those published by Smithies[5] for haptoglobin obtained by chromatography on 'Dowex 2 $X-10$', *p*H 4·2.

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PATHOLOGY

Increased Sensitivity to Bacterial Endotoxin of F_1 Hybrid Mice undergoing Graft-versus-Host Reaction

The development of graft-versus-host reaction in adult F_1 hybrid mice, following the injection of parental strain spleen cells, is accompanied by a considerable increase in the phagocytic activity of the reticulo-endothelial system[1]. Two weeks after injection of the spleen cells, the recipients were found to have phagocytic indices (calculated from the rate of clearance of colloidal carbon from the circulation) up to 10 times greater than normal. During investigations on the immunological reactivity of such animals to heterologous antigens[2], a few observations suggested that the mice were abnormally susceptible to the toxicity of relatively small doses of killed *Salmonella typhi*. Recent work has shown that stimulation of the reticulo-endothelial system in mice either by *Mycobacterium tuberculosis* (*BCG*) infection[3-5] or by repeated injections of the yeast cell-wall preparation 'Zymosan'[6] coincides with a profound lowering in resistance to the lethal effect of endotoxins from Gram-negative bacteria. In view of this association, F_1 hybrid mice undergoing graft-versus-host reaction were tested similarly for resistance to purified bacterial endotoxin, and an analogous effect has been demonstrated.

Male F_1 (*C57BL* × *CBA*) mice, weighing 20–26 gm., were injected intravenously with 75–85 million spleen cells prepared from adult male *C57BL* donors as described previously[1]. Various dosages of *Shigella dysenteriæ* type 1 endotoxin, freshly suspended in saline, were injected intravenously 14 days after the spleen cells. Previous work had shown that at this time interval stimulation of the reticulo-endothelial system was usually maximal in the strain combination used[1], although the mice appear well and indistinguishable from normal animals. The results given in Table 1 demonstrate that F_1 (*C57BL* × *CBA*) mice previously injected with *C57BL* spleen cells are 25 times more susceptible to the lethal effect of endotoxin than untreated control mice. The calculated LD_{50}'s are 11 μgm./20 gm. for treated mice and 272 μgm./20 gm. for control mice, with confidence limits at 5 per cent probability-level of 8–15 and 197–375 μgm./20 gm. respectively. All deaths occurred within 48 hr., while those mice previously injected with spleen cells which survived dosages of 2–20 μgm. endotoxin remained severely shocked for 24–48 hr. and then recovered. The subsequent onset and incidence of fatal graft-versus-host disease during the following six weeks did not seem to be influenced by the endotoxin injection at day 14.

Table 1. The effect of Graft-versus-Host Reaction induced by Injection of Parental Strain Spleen Cells on the Susceptibility of F_1 (*C57BL* × *CBA*) Mice to Bacterial Endotoxin

	F_1 (*C57BL* × *CBA*) mice	
Dose of endotoxin (μgm. per 20 gm.)	Controls	Animals given *C57BL* spleen cells 14 days previously
500	8/8*	—
200	0/8	—
100	1/8	—
50	0/8	8/8
20	0/8	7/10
10	—	8/14
5	—	1/14
2	—	0/4

* No. of mice dying
No. of mice injected

The present experiment provides a further instance, in addition to *BCG* infection and the effect of 'Zymosan' injection, where stimulation of the phagocytic activity of the reticulo-endothelial system has been accompanied by greatly increased sensitivity to endotoxin. The role of the reticulo-endothelial system in this state of hypersusceptibility should, however, remain *sub judice*, for there is much evidence (see refs. quoted in 5–7) supporting also a direct relationship between acquired resistance to endotoxin and an increase in the level of reticulo-endothelial activity. This phenomenon is the opposite of the one at present under consideration, although in both cases the phagocytic activity of the reticulo-endothelial system is raised.

The immunological basis for the graft-versus-host reaction has been clearly established by work on 'runt disease' induced in the young animal and of 'secondary disease' in radiation chimæras. But the immediate causes of the wasting and death which frequently attend it are at present unknown. Decreased resistance to bacterial endotoxin absorbed from the gut may be a contributory factor towards its pathogenesis.

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Immunological Differences of Deoxyribonucleoproteins from White Blood Cells of Normal and Leukæmic Human Beings

Experiments were performed to determine: (*a*) whether deoxyribonucleoproteins from normal and leukæmic leucocytes react immunologically with their related control sera, or whether they cross-react with them; (*b*) whether they are capable of inducing formation of antibodies in rabbits; (*c*) whether normal deoxyribonucleoproteins cross-react with sera of rabbits immunized with leukæmic deoxyribonucleoproteins and vice versa.

Isolation of leucocytes was achieved by the method of Beck and Valentine[1]. Alternatively, after sedimentation of red blood cells, citrated human plasma was centrifuged at 1,000 r.p.m. for 4 min. to recover the leucocytes. Extraction of deoxyribonucleoproteins was performed with 0·01 *M* glycine overnight after washing leucocytes with 0·01 *M* sodium citrate and 0·01 *M* glycine solution. Purification of the extract was achieved by centrifugation at 24,000*g* for 25 min. Isolation and extractions were made at 4° C. Details of this new method and biophysical and biochemical work on deoxyribonucleoproteins will be presented elsewhere. Antibodies were prepared by injecting intravenously a total amount of 25–30 mgm. of

deoxyribonucleoproteins into rabbits three times at weekly intervals. Rabbits were bled a week after the last injection. Titre of antibodies and optimal concentrations of deoxyribonucleoproteins were determined in test-tubes at room temperature. Human and rabbit sera prepared from venous blood were dialysed against 0·1 *M* glycine before use. In precipitin reactions a modified agar-gel diffusion technique of Outchterlony[2,3] was used. Agar (1 per cent), after washing with distilled water, was melted in 0·1 *M* glycine. For control purposes, it was melted in 0·01 *M* phosphate buffer and 0·1 *M* glycine at *p*H 6·8. Incubation of agar plates made at room temperature and at 4° C. yielded the same results. Each precipitin test was repeated 10–15 times.

The experiments used nine rabbits and the blood of seven normal and fourteen leukæmic persons.

Control tests of non-immunized rabbit sera with normal or leukæmic sera and deoxyribonucleoproteins of normal and leukæmic humans were always immunologically negative. No immune reaction was detected between control sera of normal and leukæmic individuals, between control sera of normal human beings and normal and leukæmic deoxyribonucleoproteins, between control sera of leukæmic humans and normal and leukæmic deoxyribonucleoproteins and between normal and leukæmic deoxyribonucleoproteins themselves. These results exclude the existence of a detectable naturally occurring immune limiting system which controls the growth of leucocytes in the blood both of normal and of leukæmic human beings.

Both normal and leukæmic deoxyribonucleoproteins were found to induce formation of high-titre antibodies in rabbits. They always gave a single precipitin line when fresh preparations were employed. Sera of rabbits immunized with normal deoxyribonucleoproteins did not cross-react with leukæmic deoxyribonucleoproteins, and vice versa (Table 1). These results show that the antibodies produced in rabbits are specific for the normal and leukæmic deoxyribonucleoproteins.

In a single instance a preparation of deoxyribonucleoproteins from a person with chronic lymphatic leukæmia gave a positive reaction with rabbit sera immunized with normal deoxyribonucleoproteins and a negative one with rabbit sera immunized with leukæmic deoxyribonucleoproteins. However, two other preparations from the same person, six months earlier, conformed to the general findings.

Table 1. Cross-Reactions of Deoxyribonucleoproteins from Nuclei of Leucocytes of Normal (NDNP) and Leukæmic (LDNP) Human Beings with their Related Antibodies (NAb, LAb) (Normal, Leukæmic)

Antigen	Antibodies						White count
	NAb_1	NAb_2	NAb_3	LAb_1	LAb_2	LAb_3	
N_1DNP*	+			−			6,800†
N_2DNP		−			−		6,500
N_3DNP		+	+		−		6,500
N_4DNP			+				8,200
L_1DNP	−			+			150,000
L_2DNP	−			+			75,000
L_3DNP		−			+		342,000
L_4DNP		−			+		202,000
L_5DNP		−			+		83,000
L_6DNP		−			+		151,000
$L_{10}DNP$		−	−		+	+	46,000
$L_{10}DNP$						+	
$L_{10}DNP$		+				−	
$L_{11}DNP$		−				+	200,000
$L_{11}DNP$		−				+	
$L_{12}DNP$		−				‡	5,000

L_1, L_2, L_3, L_5, L_{10}, L_{11}, Chronic lymphatic leukæmia; L_6, chronic myelotic leukæmia; L_4, L_{12}, acute myeloblastic leucoma.

* Numbers indicate different individuals.

† Individuals considered normal on the basis of serological tests by Central Blood Bank of Pittsburgh.

‡ Insufficient quantity of $L_{12}DNP$.

The property of deoxyribonucleoproteins from nuclei of leucocytes of normal and leukæmic human beings of inducing formation of specific antibodies in rabbits is not restricted to these deoxyribonucleoproteins alone, but it is a property of deoxyribonucleoproteins from widely different sources (sea urchin, calf thymus, tumours). These results will be presented elsewhere.

The specificity of antibodies to normal and leukæmic deoxyribonucleoproteins indicates the existence of a structural difference between the deoxyribonucleoproteins. This specificity, at the same time, argues for the nativity of these preparations; and it implies a genetic differentiation of the nuclear deoxyribonucleoproteins in the growth of white blood cells.

It is hoped that these findings may stimulate the genetic approach to the study of leukæmia and cancer.

I wish to thank the Department of Biophysics for the use of its facilities and Dr. Frederick I. Tsuji for his help.

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Correlation between Ulcerative Colitis and *Rh* Blood Groups

Winstone, Henderson and Brooke[1] did not find ulcerative colitis to be correlated with the *ABO* blood groups, secretor status, or the rhesus factor. Their *Rh* classification was, however, restricted to rhesus-positive and rhesus-negative, presumably based on the use of an anti-*D* serum only. When we recently examined 185 patients in whom ulcerative colitis had led to colectomy, we also did not find any particular relation to *D* status, but did find, considerably to our surprise, a definite correlation with the homozygous *CC* rhesus type. Using as controls Wiener's series of 1,071 New York Whites[2], we obtained the results shown in Table 1.

Table 1

	Rhesus type			Total
	CC	*Cc*	*cc*	
Patients with colectomy	51	97	37	185
Normals	209	502	360	1,071

From these figures a value of χ-square with two degrees of freedom of 15·214 was calculated; this value is very definitely significant (P about 5×10^{-4}). So far as we could judge, the group of patients we tested did not differ in ethnic composition in any notable way from our controls. There is, however, evidence of heterogeneity in our test material ($\chi^2_{(10)} = 19{\cdot}115$, $0{\cdot}05 > P > 0{\cdot}02$). No correlation was found with *ABO*, *MN*, or secretor status.

We plan to extend these investigations and publish a more complete account elsewhere.

We are very grateful to the members of QT, Inc. (The Ileostomy Association of Boston), and the Ileostomy Associations of New York and Chicago for their generous and invaluable co-operation.

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BIOLOGY

Molecular Biology or Ultrastructural Biology?

In a recent communication[1], Prof. C. H. Waddington protests against the increasing use of the name 'molecular biology' for a large and ever-growing field to which, he argues, it does not apply, and suggests confining it to more restricted topics for which in any event a better name would be 'ultrastructural biology'. Since, as I believe, I was responsible for first propagating the name 'molecular biology', and its widespread adoption seems to date particularly from my 1950 Harvey Lecture "Adventures in Molecular Biology"[2], it may be worth while stating again what I personally had in mind. In that lecture I said that molecular biology, as I envisaged it, "implies not so much a technique as an approach, an approach from the viewpoint of the so-called basic sciences with the leading idea of searching below the large-scale manifestations of classical biology for the corresponding molecular plan. It is concerned particularly with the *forms* of biological molecules, and with the evolution, exploitation and ramification of those forms in the ascent to higher and higher levels of organisation. Molecular biology is predominantly three-dimensional and structural—which does not mean, however, that it is merely a refinement of morphology. It must at the same time inquire into genesis and function".

I was inspired, obviously, by our early X-ray and accessory adventures at Leeds in demonstrating, for example, the folding and unfolding of protein chains and the nature of the long-range elasticity of mammalian hairs; the classification of the fibrous proteins into two principal configurational families—the *k-m-e-f* group and the collagen group; the similarity between the keratins of birds and reptiles which distinguishes them from the mammals; the apparent common configurational plan underlying the elastic and contractile properties of hair, epidermis, muscle and (more recently) bacterial flagella; the interpretation of protein denaturation and the relation between the fibrous proteins and the globular proteins (as we called them); the detailed exploration of the cellulose fabric of the cell wall of the alga *Valonia ventricosa*; first studies of the structure of the nucleic acids and nucleo-proteins, etc. Of later years, other examples of how we have continued along the same general line of thought are Rudall's work on the molecular structure of types of cuticles and of the various kinds of silks and other cocoon proteins[3], and Pautard's investigations into the problem of biological calcification, from ciliates to cetaceans, with his latest X-ray demonstration that the organic matrix of tooth enamel is not a collagen (as it is with dentine and bone) but is more like a member of the *k-m-e-f* group[4].

I trust that Prof. Waddington will not mind my recalling in this way our original concept of molecular biology, and will agree that we have kept fairly faithfully to it. It is impossible, though, to embark seriously on work of this kind without being interested in, and becoming more and more involved in, numerous associated studies, with the result that, as has happened, there soon comes a time when there seems to be no end to the business. Molecular biology has now inevitably spread to all aspects of biology looked at from fundamental molecular viewpoints—and thus includes 'molecular genetics', for example, if I may dare suggest it; and it is difficult to maintain that such an eventual extrapolation is unwarranted, for it is simply saying that that is the coming biology.

After all this it might well be asked, Why then is our laboratory at Leeds called the Department of Biomolecular Structure? The answer is that, when in 1945 I was appointed professor, the university committee considering me, and from which I was naturally excluded, preferred the name 'biomolecular structure' to 'molecular biology', which was what I myself wanted. Presumably, a majority of the members of that committee held opinions similar to those expressed by Prof. Waddington, and I offer this argument in his support; though I will confess that a probably more candid, and conceivably better justified, assessment that leaked out to me was that "he may know something about molecules but he knows precious little about biology". The answer to that one of course, in the tiresomely good old words, is that it all depends on what you mean by biology.

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Of all the recently developed types of analytical biology, the field of which Prof. Astbury was one of the main initiators has probably the best claim to the title 'molecular biology'. But even granting this, it is as well to remember that it was just because Astbury went on from the study of well-defined molecules to investigate entities such as hairs, which can at best by courtesy be called molecular, that he was able to open the doors through which so many people are now passing. If we want a title for the whole field of which Astbury's work forms a part, but which includes also the study of genes, microsomes, endoplasmic reticulum, antibodies and so on, by techniques only a few of which are definitely chemical, then I submit that

we require a name which is more inclusive than 'molecular biology'.

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Feather Lipids

The plumage of fourteen widely differing species of birds excepting that of a ratite, the emu (*Dromaeus novae-hollandiae*), contained approximately 2 per cent of lipids which were readily extractable with ether or chloroform. The primitive plumage of the flightless emu yielded only 0·4 per cent lipids.

These feather lipids were found to contain cholestanol, cholestanylstearate and other steroids. Cholestanol and its esters contaminated by cholesterol were found in all fourteen species examined in amounts of about 7–15 per cent of the total feather lipids expressed as cholestanol[1]. Non-steroid esters, the alcoholic components of which varied with species, were also present. For the duck these consisted mainly of octadecanol and eicosanol. However, the greater part of the feather lipids was made up of free optically inactive fatty acids, with a chain-length of 7–22 carbon atoms. The most prominent of these were palmitic and stearic acid.

The outstanding features of the chemical composition of the bird's feather lipids are their unexpectedly high cholestanol content and the large amount of free fatty acids. Usually, cholestanol is but a small fraction of the cholesterol present in vertebrate tissue and the bulk of the fatty acids is esterified.

Feather lipids are of dissimilar qualitative composition to preen or oil gland secretion, except for the octadecanol fraction of some birds. In these cases this fraction is still quantitatively different as, for example, in the duck, where octadecanol esters comprise about 90 per cent of the entire oil-gland secretion[2] and the total feather lipids only contain about 10 per cent.

The quantitative composition of feather lipids from any one bird varies according to the type of the feather and the part of the feather examined. For example, in the duck, small feathers have a relatively high octadecanol-eicosanol ester content (17 per cent) while the large tail and wing feathers contain only about 1 per cent of this fraction. The compact shafts of large feathers are characterized by a large amount of free cholestanol (16 per cent), while the barbs contain only about 4 per cent (Table 1).

Table 1. Composition of Feather Lipids (Duck)

	Cholestanol (per cent)	Cholestanyl esters (per cent)	Octadecanol fraction (per cent)	Fatty acids (per cent)
Small feathers	5	12	17	57
Large feathers	10	7	2	82
Barbs of large feathers	4	7	1	90
Shafts of large feathers	16	6	1	76

With no sebaceous glands in the bird's skin other than the preen gland, which may not be present (dove, emu, etc.[3]) the feather lipids found in the plumage are considered to be a by-product of the keratinization process apparently being formed with the feather as it develops. They are water-repellent enough to take the place of the secretion of the preen gland. Thus, water birds which had their oil gland removed surgically remained dry[4], because the feather lipids functioned as water-repellents. In the controversy about the water-repellent properties of bird-feathers the role of the feather lipids has apparently been overlooked.

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α-Conarachin

It is generally considered that the major globulins of dicotyledons and the prolamins and glutelins of monocotyledons are reserve proteins, that is, they are digested enzymatically on germination, whereupon the amino-acids and peptides are made available for protein synthesis[1]. Actually, all the protein in the storage organ of the seed eventually disappears, as does the organ itself. But the label of reserve protein has been put on those proteins, small in number, which comprise a relatively large percentage of the total protein, which change early in germination, and which possess no obvious biological activity. Reserve proteins would be expected to have a characteristic pattern of metabolism on germination; ultracentrifuge patterns of protein extracts of pea-seeds at various stages of germination showed more rapid disappearance of the globulins[2], but this technique is not sufficiently discriminating to identify specific proteins with the pattern of change.

We have been able to achieve better identification of changes on germination with specific protein fractions of the peanut (*Arachis hypogaea*) by means of chromatography on DEAE cellulose. One fraction that changes its properties early on germination was isolated and named α-conarachin. It approaches monodispersity by standards of chromatography and ultracentrifugation.

The two major groups of globulins mentioned most often in the literature on peanut proteins are arachin, precipitated at 40 per cent saturation with ammonium sulphate from a salt extract of the peanut, and conarachin, precipitated by 85 per cent saturation of the supernatant after removal of arachin[3]. Both these fractions prepared from *NC2* variety peanuts were dissolved in phosphate buffer, *p*H 7·9, $\mu = 0{\cdot}06$, and chromatographed on DEAE cellulose ('Selectacel', Brown Co.) by the procedures of Sober *et al.*[4]. Elution was with a linear gradient of 0–0·6 *M* sodium chloride; protein analysis was by the method of Lowry *et al.*[5].

Chromatography patterns of the two fractions are shown in Fig. 1*A*; a pattern of an extract of the globulins from peanut cotyledons in the same buffer is shown in Fig. 1*B*. We have grouped the proteins into four arbitrarily selected fractions: the first is that which is not adsorbed on the cellulose; the second is eluted by salt concentrations up to 0·14 *M*; the third is eluted in the range of 0·14 to 0·23 *M*; and the fourth by concentrations of salt above 0·23 *M*. Arachin is mostly of group IV; conarachin comprises groups I, II, and III.

With the same chromatographic techniques, observations were made of changes in the proteins of peanut cotyledons after three days germination at

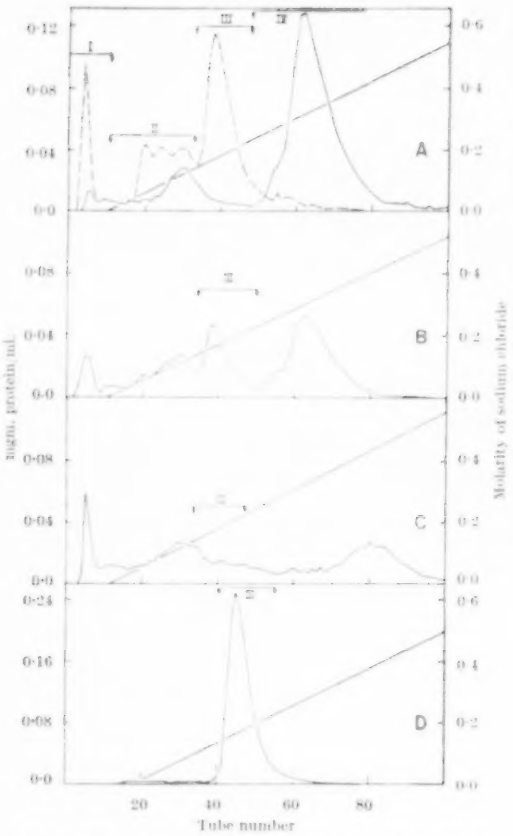

Fig. 1. Chromatography of peanut protein fractions on DEAE cellulose. 10 mgm. of each sample were put on 2 gm. of cellulose. The straight line indicates the sodium chloride gradient as measured on the eluate. *A*, Full line represents arachin fraction; broken line, conarachin fraction; *B*, extract of proteins from peanut cotyledons with buffer, *p*H 7·9, $\mu = 0{\cdot}06$; *C*, extract of proteins from cotyledons of germinated peanuts with same buffer; *D*, α-conarachin

25–28° C. Examination of the results given in Fig. 1*C* shows that the globulins of group III disappeared almost entirely from the chromatograph; there was an increase in the salt concentration at which the globulins of groups II and IV were eluted and a reduction in the relative amount of group IV; the proteins of the first group were mostly unchanged. We have no evidence yet of the nature of the changes that cause the disappearance of group III from the chromatogram; these may be selective hydrolysis of this protein or may arise from changes such as deamidation, which would result in an increase in negative charge at the *p*H of chromatography. Indeed, only 70 per cent of the proteins were recovered from the chromatogram when those of the germinated seed were examined as compared with 99–95 per cent from the resting seed. By using a higher concentration of salt and higher *p*H, other proteins were recovered from the column, but their relationship to the original protein has not been established.

The major protein of group III was purified by chromatography as follows: 250 mgm. of the conarachin fraction were dissolved in phosphate buffer at *p*H 7·9, ionic strength 0·06, dialysed for 24 hr. against the same buffer, adsorbed on a column (4 gm.) of DEAE cellulose, and chromatographed with 1,200 ml. of eluant under a linear gradient of 0–0·1 *M* added sodium chloride. This is a much gentler gradient than that used for the analytical chromatography. The eluate was discarded; a fresh gradient of 400 ml. of 0·1–0·2 *M* added sodium chloride served to elute the desired fraction. The middle portion of the eluate was saved, rechromatographed and concentrated; the yield was 30 per cent of the original conarachin fraction.

Chromatography of this fraction showed the presence of only one component (Fig. 1*D*); it contains 15·3 per cent nitrogen.

In buffer of ionic strength 0·5, *p*H 7·9, α-conarachin sediments as one component with an apparent sedimentation constant of 7·8; at $\mu = 0{\cdot}06$, the sedimentation constant is 12·6; at intermediate ionic strengths, the pattern is a mixture of these two species. With the same constants as assumed for peanut protein by Johnson and Naismith[6], molecular weights of 142,000 and 295,000 were calculated for the two species. This confirms and extends the observations of Johnson and his associates that there are components of the peanut proteins which undergo association-dissociation.

Further work on the chemistry and on the metabolism of α-conarachin during germination might be expected to provide more information on the nature of reserve proteins. A full account of this and related work will be published at a later date.

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Use of Agar Diffusion and Fluorescent Antibody

The agar diffusion technique is very useful and has made a significant contribution in the analysis of antigenic materials. However, the difficulty encountered when trying to observe some of the precipitation zones is known to anyone who has used this method. Successful photography of the zones can be especially difficult to achieve.

By using fluorescent antibody in the agar diffusion procedure, the precipitation zones when viewed or photographed in the near ultra-violet range appear much clearer than with non-fluorescent antibody.

Fig. 1 shows the zone pattern of the plate on the right when photographed using fluorescent antibody and specific antigen. The plate on the left contains fluorescent antibody and non-specific antigen. Fig. 2 depicts the same materials when photographed without fluorescence.

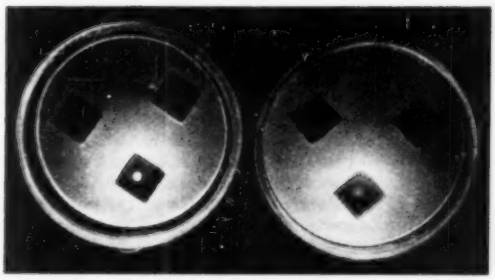

Fig. 1. Photographed using 'black light' and fluorescent antibody

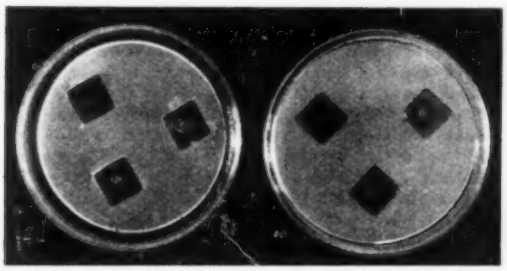

Fig. 2. Photographed using visible light without fluorescence

The method may be especially helpful if the concentrations of either of the reactants are limited.

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An 'Apical Body' in the Galea Capitis of the Normal Bull Sperm

WORK on the ultrastructure of the bull sperm[1] has been continued on semen from normal, fertile bulls of the Red Danish Milk-breed. These earlier investigations were performed on bull semen kept on ice 24–48 hr. prior to osmium fixation.

More recently we have attempted to get the semen samples centrifuged as soon after the ejaculation as possible, and two specimens have been fixed (1 per cent osmium tetroxide) within 30 min. In such freshly prepared material the following new observations on the head of the bull sperm have been made.

Due to the characteristic tennis racket-like shape of the head (dimensions 8 × 4 × 0·5μ), complete coronal sections through the full flat area of the sperm head have only rarely been encountered.

For this reason more has been learned from the study of the sagittal sections such as those shown in Fig. 1*A*. An especially well-preserved median sagittal section of this type is marked with an arrow, and the schematic drawing (Fig. 1*B*) is based on this and similar photomicrographs.

The illustrations show that the sperm head contains a dense nucleus 0·2–0·3μ in thickness (*a*–*b*) with a somewhat thicker base (*a*) and a sharp-pointed apex (*b*) which forms a front edge. The basal half of the nucleus is covered by a rather thin but relatively electron-dense post-nuclear cap (*c*).

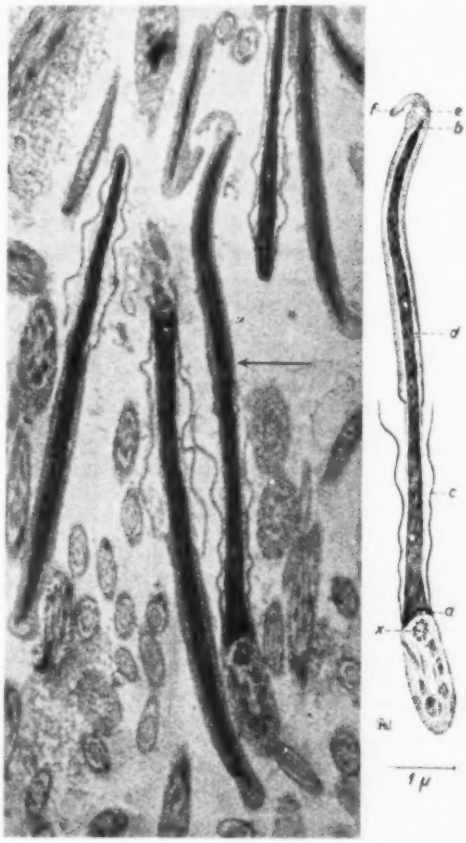
The apical half of the nucleus is covered by a somewhat thicker (about 0·1μ) and less electron-dense cap : the galea capitis (*d*). This structure has been described earlier[2] in the detached state in a light microscope study of the bull sperm.

Along the front edge of the sperm head the galea capitis forms a characteristic thickening, which we have chosen to name the apical body (Fig. 1*B*, *e*–*f*).

Our investigations indicate that the galea capitis with its apical body and the post-nuclear cap are completely enveloped by the cell membrane of the sperm, which thus covers the entire cell without interruption from the head to the tip of the tail. Further details of this morphological feature will be published elsewhere.

The apical body consists of a more or less closed fold (*f*) and a thickening in which a narrow cylindrical body or vacuole is situated (*e*). This presents a somewhat smaller density than the rest of the galea capitis, and seems to lie parallel with the fold along the front edge of the sperm head.

In the median section of Figs. 1*A* and *B*, the fold is seen as a hook-formed element and the vacuole as an oval less-dense area with a diameter of about 0·1μ.



A B

Fig. 1. *A*, Electron micrograph (× *c*. 10,000) showing sagittal sections of several sperm heads from a normal, fertile bull. The head marked with an arrow is a median sagittal section including the proximal centriole at the base of the nucleus and the apical body at the front edge of the head. In four of the other sagittal sections the apical vacuole is visible. *B*, Schematic drawing of a median sagittal section of the sperm head: *a*, base of the nucleus; *b*, apex of the nucleus; *c*, post-nuclear cap; *d*, galea capitis; *e*, apical body with the apical vacuole; *f*, fold of the apical body; *x*, proximal centriole. (Drawn by Poul H. Winther)

Often the fold is more acutely bent towards the sperm head proper than shown in Figs. 1*A* and *B*, and frequently the space between the fold and the rest of the galea has been almost closed.

At higher magnification the morphology of the apical body just described has been verified in sections of 12 individual sperm heads from 3 different bulls.

A similar structure has also been demonstrated in the galea capitis of rabbit sperm.

Most likely the apical body of the galea capitis in the bull sperm is a very delicate structure, so delicate that it can only be preserved and thus demonstrated in sperm fixed in the living state. Examination of the electron micrographs of unsectioned bull sperm published by Hancock[2] seems to present some support for this interpretation. The front edge of the head of a cell fixed in the living state (shown in plate 19*a* of Hancock's paper) contains a structure which could very well be identified as the apical body described in this communication, whereas the head of a sperm which was dead prior to preparation for electron microscopy and which is illustrated in plate 19*b* of the paper shows no evidence of this structure.

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Structural Asymmetry in Cilia and Flagella

It has become possible recently to describe the fine structure of cilia and flagella in more detail than was feasible before, and a characteristic structural asymmetry has been noted in the flagellum of certain flagellates[1]. This communication reports a similar asymmetry in cilia and flagella of a wide range of organisms.

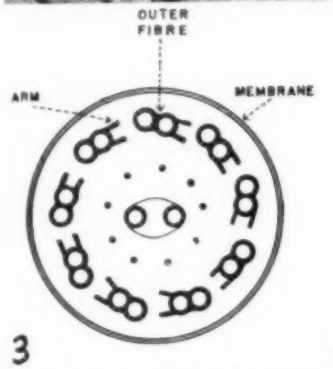
The material investigated includes the ciliate *Paramecium multimicronucleatum*, and ciliated epithelia from mussel (*Anodonta cataracta*), frog (*Rana pipiens*) and the rat. Further observations are reported on the flagellates *Holomastigotoides*, *Pseudotrichonympha*, and *Trichonympha*. For convenience, the term 'cilium' will be used here to include the flagellum of these flagellates.

The cilia are cylindrical structures containing a complex array of fibres oriented longitudinally. Their asymmetry results from the arrangement of the nine outer fibres (Figs. 1, 3). In transverse sections of the cilium each outer fibre appears as a doublet with a figure-of-eight cross-section and bears two projections, or 'arms', that extend towards one adjacent outer fibre. These arms point in the same direction on all the fibres in a given cilium. This configuration could exist, theoretically, in two enantiomorphic forms; the clockwise form may be defined as that in which, to an observer looking outwards along the cilium from base to tip, the arms all point in a clockwise direction. In the basal body, at the cytoplasmic end of the cilium, the arrangement of the outer fibres is different, but again asymmetrical. Here the fibres are triplets; they do not bear arms, but each fibre is tilted inwards at about 40° to the overall tangent to the basal body. The relationship between basal body and cilium is such that in the clockwise form (as defined here), the configuration shown in Figs. 2 and 4 is seen by an observer looking outwards from the end of the basal body that lies deepest in the cytoplasm[1]. All these structural features are essentially the same in cilia of all the organisms examined.

In order to determine whether a cilium has the clockwise or counter-clockwise form it is necessary to examine in the electron microscope an accurate cross-section of known absolute orientation. With *Paramecium*, random sections were cut and the orientation determined in the microscope from the known asymmetry of the kinetodesmal fibrils[3]. With the other organisms it was necessary to know the orientation in which a section was cut from the specimen, and to keep track of it through later manipulations.

The asymmetry has been observed in six individuals of *Trichonympha*, one *Pseudotrichonympha*, one *Holomastigotoides*, and six *Paramecium*; gill epithelium from four mussels; pharyngeal epithelium from one frog; tracheal epithelium from six rats. The following results were obtained:

(1) So far as could be determined, all the cilia in any one specimen had the same enantiomorphic form (an average of about fifty cilia were examined in each specimen).



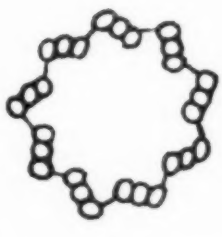


Fig. 1. Electron micrograph showing a cross-section of a cilium in *Holomastigotoides*
Fig. 2. Electron micrograph showing a cross-section of a basal body in *Holomastigotoides*
Fig. 3. Diagrammatic reconstruction based on Fig. 1
Fig. 4. Diagrammatic reconstruction based on Fig. 2

(2) All specimens had cilia of the clockwise form. This apparent uniformity in such widely separate groups of animals suggests that all cilia, whatever their source, have the same clockwise form. However, the occasional occurrence of the counter-clockwise form cannot be excluded.

Essentially the same arrangement of doublet fibres bearing arms occurs also in many sperm-tails, for example, from the sea-urchin[3], butterfly[4], and rat (Gibbons, I. R., unpublished observations). (The frequent presence of extra components not found in cilia is irrelevant to the present consideration.) It seems probable that sperm-tails will show the same uniformity of asymmetry as cilia, but the difficulty of determining the absolute orientation of cross-sections has so far prevented examination of this point.

For a number of years it has been known that the movement of spermatozoa from many animals is asymmetrical[5,6]. The most obvious, though not the most fundamental, expression of this is seen when freely swimming sperm come into contact with an obstructing surface: they usually move around on it in counter-clockwise circles (as seen on looking towards the surface). More recently, Parducz[7] has described a characteristic counter-clockwise motion of the cilia of *Paramecium*. Such asymmetry of movement might perhaps be related to the structural asymmetry that has been described here.

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Genetically Mixed Perithecia in *Neurospora*

SANSOME[1] has produced evidence that the asci in a single perithecium of *Neurospora crassa* may originate from more than one pair of gamete nuclei. Despite Sansome's evidence, it has been accepted generally that there is only one egg and one sperm nucleus[2].

Sansome used a heterocaryon as one of the parents in her experiment, so that the genetically different sperm nuclei in each perithecium could have originated from a single multinucleate cell. If one accepts Sansome's results, the question still remains whether or not the sperm nuclei in the ascogenous hyphae of a single perithecium can originate from two or more different conidia. An answer to this question is presented here by using an ascospore colour mutant *ts* (tan-spore)[3].

A mixed suspension was made of approximately equal numbers of conidia from a *ts* culture and from a wild-type culture, both of mating type *A*. This suspension was used to fertilize protoperithecia, which had developed from a wild-type culture of mating type *a* on Westergaard and Mitchell's minimal agar medium[4]. More than seventy-five conidia were applied per protoperithecium. Fertilization was carried out within 5 min. after the mixed suspension was prepared to prevent formation of heterocaryons by the germinating conidia. The average number of nuclei in those two kinds of conidia was determined by Huebschman's method[5] to be 2·6 and 2·7 respectively. After the perithecia had matured, 2,778 perithecia were dissected and examined under the microscope. All the perithecia examined were observed to have a single ostiole. Those with two or more ostioles were discarded.

Fig. 1. Ascus cluster from a mixed-type perithecium, showing wild-type and segregating asci (the asci containing eight colourless ascospores are immature).

The great majority of these perithecia were homogeneous types, that is, they consisted entirely of asci segregating for *ts* and wild-type, or entirely of asci in which all the ascospores were wild-type. There were 1,231 perithecia homogeneous for the segregating asci, and 1,487 homogeneous for the non-segregating asci. Sixty perithecia, however, were found to be heterogeneous, containing both segregating and non-segregating asci (Fig. 1). The mixed perithecia indicate that two or more sperm nuclei from two or more conidia can be involved in the formation of a single perithecium. The frequency of heterogeneous perithecia (2 per cent) would indicate that at least 4 per cent of perithecia result from protoperithecia that have been fertilized by two or more conidia. This frequency is considerably lower than that reported by Sansome, who found four heterogeneous perithecia in a total of eight perithecia examined.

A count of the mature asci in 51 of the heterogeneous perithecia gave 933 of the non-segregating type and 692 of the segregating type. This differs significantly from a 1 : 1 ratio ($\chi^2 = 35{\cdot}7$, $P < 0{\cdot}001$), showing an advantage of the former during the time of ascus formation. The ratio of the two types of homogeneous perithecia also deviates significantly from a 1 : 1 ratio ($\chi^2 = 24{\cdot}1$, $P < 0{\cdot}001$), indicating a selective advantage of the wild-type nuclei over the *ts* nuclei for their entrance into the protoperithecium. Further analysis, at present being carried on by one of us (T. E.), shows that the ratio is affected in various ways by the stocks utilized in the crosses, indicating that a number of factors are involved in this phenomenon.

When this manuscript was in preparation, our attention was directed by Dr. D. D. Perkins to the unpublished work of Grant[6]. Grant obtained results very similar to those reported here. She obtained 2

heterogeneous perithecia from a total of 106 examined. One of these two, however, had two ostioles and was double the normal size, indicating that it was the result of the fusion of two separate trichogyne systems.

The supervision of Prof. T. Haga is greatly appreciated. Criticisms and corrections to the manuscript were supplied by Drs. D. D. Perkins and C. S. Gowans.

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Flower Initiation in *Trifolium repens* L. : a Short-Long-Day Plant

Past investigations into the photoperiodic control of flowering have led to the conclusion that *T. repens* is a long-day plant with a critical day-length of approximately 13·5 hr.[1]. It is also known that the response to photoperiod varies with temperature[2,3], the critical day-length being much shorter at low than at high temperatures. Investigations reported here now show that *T. repens* reacts as a typical short-long-day plant.

In a series of preliminary experiments, seedlings of New Zealand Government Stock white clover, grown at average temperatures of 20° C. at night and 25° during the day, failed to flower in long days unless they had previously received short days for at least 4 wk. Thus the response of *T. repens* to day-length is similar to that of *Campanula medium*[4] in which short days are necessary for the attainment of ripeness-to-flower before long days lead to the initiation of inflorescence primordia. Within the strain of clover used, however, 5–10 per cent of the individual plants fail to respond to day-length in any way.

A series of more detailed investigations was made into the nature of this short-long-day reaction system in clonal material from the same source. Ramets of two selected clones of white clover, *A* and *C*, were grown in glass-houses in which the temperature varied between minima of 15° and 21° C. at night and maxima of 21° and 32° C. during the day. Four day-length treatments were imposed: SDs (8-hr. photoperiods; plants darkened from 4 p.m.–8 a.m.); NDs (unsupplemented natural daylight providing photoperiods which decreased from 13 to 11 hr. during the experimental period); LDs (16-hr. photoperiods consisting of natural daylight supplemented from 4 a.m. to 8 a.m. and from 4 p.m. to 8 p.m. by artificial light); and CL (continuous light consisting of natural daylight supplemented by artificial light from 4 p.m. to 8 a.m.). Supplementary illumination was provided by 200-W. 'Sieray' mercury vapour lamps ballasted with a tungsten filament which gave an intensity of approximately 500 ft.-candles at the leaf surfaces.

In the first experiment, plants were exposed to either NDs or LDs for a preliminary period of two months and then transferred into either LDs or NDs. There were thus four groups of plants, each consisting of three ramets of each clone, which received NDs followed by LDs, NDs followed by NDs, LDs followed by NDs or LDs followed by LDs. Flowering was recorded on twenty vigorous runners from each ramet. Plants transferred from NDs to LDs produced an average of 0·82 flower head per runner in clone *A* and 0·91 in clone *C* as an immediate response to such treatment. No initiation of inflorescence occurred on the plants of any other group; 9 months after their period of preliminary treatment these were still entirely vegetative.

The first morphological sign of the transition of a vegetative apex to the reproductive state in white clover is the precocious development of a bud in the axil of the youngest leaf primordium. Such a bud appears in the axil of the first leaf primordium to be initiated at the apex of a ripe-to-flower runner after its transfer from short to long photoperiods. Following its initiation, this bud develops rapidly into a lateral inflorescence and the main stem apex reverts to the vegetative condition. This pattern of development is identical to that occurring in other *Trifolium* species[5,6].

The minimum requirement for both short days and long days has been determined by more recent investigations. The response to short days was tested by growing twenty plants of clone *A* for 2 months in LDs, exposing them to 0, 3, 6 or 14 SDs, and then returning them to LDs. The results (Table 1) show that in some circumstances initiation of inflorescence can occur in LDs after a preliminary exposure to as few as three SDs.

Table 1. The Effect of Treatment with Short Days on Inflorescence Initiation afterwards in Long Days

No. of short days	0	3	6	14
Average number of inflorescences per runner Standard error	0·000 ± 0·000	0·105 ± 0·052	0·812 ± 0·098	1·595 ± 0·085

The sensitivity to long days is even greater than to short days. The combined results of two experiments to determine the minimum number of long days necessary to bring about inflorescence initiation are shown in Table 2. In both experiments plants of clone *A* which had been grown in NDs for 3 months immediately before treatment were exposed to a period of CL and then returned to NDs. Under these conditions a single day of CL was sufficient to induce the initiation of inflorescence primordia.

Table 2. The Effect of the Duration of Exposure to Continuous Light on Subsequent Inflorescence Initiation in Short Days

No. of days continuous light	0	1	2	4	6
Total number of runners	54	100	18	18	18
Percentage of runners bearing inflorescences	0	94	100	100	100

Some individuals within a population of New Zealand Government Stock white clover are thus very sensitive short-long-day plants at the temperatures used during the present investigation. Ripeness-to-flower will only occur in short days and, once this condition is attained, a single long day is sufficient to bring about inflorescence initiation. A comparable sensitivity to long days has so far been reported to occur in only one long-day plant: *Lolium temulentum*[7].

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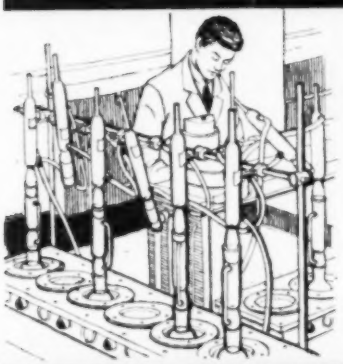

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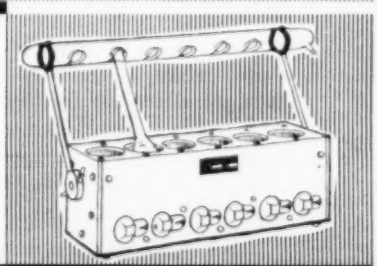

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Further investigations into the nature of the short-long-day reaction system are in progress and will be reported in detail elsewhere.

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Early Flower Initiation in the Banana

THE commercial banana is typically seedless and must be propagated vegetatively by lateral buds which appear on the true stem at the base of a large plant. Depending on climate and season, a flower bud appears when the pseudostem is 12–20 ft. tall (variety Gros Michel) and only after a succession of more than 40 leaves. Recently, however, on farms of the United Fruit Co. in Guatemala and Honduras, shoots have flowered when only 2–3 ft. tall, while still attached to the base of a 'mother' plant, and following the production of seven or fewer leaves.

These fruited suckers were noted in the field in conjunction with the application of a rapid method of banana multiplication[1], which is based on the forcing of immature lateral buds while harvesting the more matured buds as vegetative 'seed'. By this means up to 24 propagules have been obtained from a single planted bit within a year. The majority of these forced suckers have been normal and have flowered after the appropriate vegetative period. However, in at least 21 instances lateral buds have produced fruits after an abbreviated vegetative period and while still attached to the parent.

The circumstances surrounding this early flowering were investigated in Guatemala. Invariably the fruited suckers appeared as lateral shoots from the base of plants that were themselves in flower. Invariably the suckers developed from the latest formed viable buds—those appearing close to the terminal apex and passing through their early development at the time of the conversion of the apical parental bud to the flowering state. No more than one flowering sucker has ever been observed to be attached to any single parent plant and all have been noted on the variety, Cocos, a dwarfed sport of the Gros Michel.

The fruited small suckers generally were of normal appearance but dwarfed in size, as in Fig. 1. There were a number of variants; some produced a series of bladeless leaves enclosing anomalous structures that resembled lateral inflorescences yet showed no flowers; a few flowered directly without any leaves. Most significantly, however, all produced the terminal and clearly recognizable flower bud very early.

In three respects the plants involved were treated differently from similar plants grown in similar areas. All were wounded heavily and continuously in connexion with the multiplication technique. All were provided with an extremely high level of nitrogen, as urea, applied as a side dressing. Immature buds proximal to the parental apex were forced at the time of the conversion of the parental bud to the flowering state.

Fig. 1. Small, fruited sucker. The form is normal, however, the number of vegetative leaves preceding the inflorescence has been reduced to 7 and the number of flowers sharply decreased. Note the size relative to the hand and the parent pseudostem

It is not likely that the luxury supply of nitrogen would be concerned since classically this would favour vegetative development and suppress reproductive tendencies. The heavy wounding must not entirely be discounted since the stimulatory effect of wounding on plant and cell activity is well documented[2–4]. In addition, it has been noted that field banana fruiting abnormalities are almost invariably associated with wind damage, insect injury, machete cuts, or disease incidence. However, the rarity of such abnormalities would suggest that the response could only be elicited when the apex was in a susceptible stage.

The third possibility relates the conversion to flowering of the parental terminal bud to a simultaneous, but often less-efficient, induction by the same stimulus of a proximally located forced lateral bud. In untreated plants (not undergoing multiplication) such buds would be rudimentary and would never develop to form a shoot. In treated plants, and even so in rare instances, buds sufficiently advanced to be influenced by an overflow of the parental conversion factor are located sufficiently near to respond. These may then be imperfectly or wholly converted to the flowering status by the parental stimulus. Hence in the subsequent development of the lateral shoot, where this is permitted, the newly acquired character is manifest as either a perfect or anomalous inflorescence, with the number of preceding leaves dictated by the status of the bud at the time of its conversion.

Pertinent to this is a body of literature concerning lateral inflorescences in the banana[5]. Invariably these have appeared in conjunction with the flowering of the main axis and have involved buds very close to the terminal bud. The rarity of such occurrences in the field undoubtedly relates to the observation of Skutch[6] that buds do not form along the elongated true stem of the fruiting banana. Should buds occupy sites along the elongated axis, and should their later development occur, then the lateral inflorescences of Ghosh[5] could be explained by the overflow mechanism outlined above.

The occurrence of these early flowers is important from the point of view of the theory of flowering. For

some years attempts have been made at influencing the onset of flowering in the banana, as has been done in the pineapple[7,8], but without success. The conversion of these young buds at such an early stage indicates that there is a good probability that the meristem of older plants also can be influenced if treated appropriately. The benefits of such control over the fruiting habits of a commercial crop need not be discussed.

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ENTOMOLOGY

Control of the Responsiveness of the Blowfly to Water

'Hunger' in the blowfly (*Phormia regina*, Meig.) has been the subject of several studies. The present experiments were undertaken to examine the related problem of 'thirst' or the control of water intake. Bolwig[2] showed that blood osmotic pressure was correlated with responsiveness to water applied to the tarsi of a fly. Wolbarsht[3] suggested that the response of the contact chemoreceptors to water was increased in desiccated flies. Since ingestion is primarily controlled by the taste receptors[4], such a relationship would provide for a direct and specific regulation of water ingestion.

Flies, if dehydrated enough, reflexively extend their proboscis on contact of the tarsal or labellar chemoreceptors with water. Normally, taste thresholds are expressed as the effective concentration of the test substance in solvent. In the present case, the number of flies that responded to water was the measure used. Only those flies were included that were either uniformly negative or positive on each of three tests before treatment. Dehydration was accomplished by confinement of the flies over calcium chloride in a sealed vessel. Water-negative controls were members of the same population that had been kept in the normal room atmosphere or that had been given water after desiccation. Injections were given as described by Evans and Dethier[4]. Unless stated otherwise, tests were performed within 5 min. after the injection (Table 1).

Water-positive flies were rendered negative by injections of distilled water into the haemocoel (exp. 1–3). The effect was immediate (exp. 1–3) and persistent (exp. 4) and depended on the volume injected (exp. 3, repeated injections). Injection of small (exp. 5 and 7) or large (exp. 6) volumes of hyper-osmotic solutions into the water-negatives did not render them positive. On the other hand, these same injections did, like distilled water, make positive flies negative (exp. 8–11). Some of the treatments produced a high mortality, but the effects on the water response appeared specific since the flies would respond normally to dilute sugar solutions after the most severe treatment (exp. 3, 5, 6).

Table 1. Effect of Injections on Responses of the Blowfly to Water

Experiment No.	No. of flies	Response before treatment	Injected †	No. negative after treatment
1	35	+	2·5 μl. water	6
2	52	+	8 μl. water	44
3	27	+	2 μl. water	2
			2 μl. water	6
			2 μl. water	18*
4	26	+	3 μl. water	
			immediately	15
			at 10 min.	15
			at 60 min.	14
5	120	−	3 μl. 2 *M* glucose	98*
6	116	−	7 μl. 2 *M* glucose	111*
7	29	−	2·4 μl. 4 × saline	29
8	53	+	3 μl. 4 × saline	29
9	69	+	3 μl. 2 *M* glucose	38
10	28	+	3 μl. 2 *M* glucose in saline	14
11	25	+	6 μl. 2 *M* glucose in saline	21

* Responded afterwards to 0·1 *M* sucrose.
† Water indicates distilled water; the saline was Bodenstein's (ref. 9); 4 × indicates saline four times more concentrated.

Since, however, all the foregoing procedures that were effective blocked a response and none elicited one, it was crucial to reduce blood volume and thereby elicit responses to water. The only effective method of bleeding *Phormia* is to cut off the forelegs near the base and compress the thorax on all sides[4]. In this way up to half the blood can be expressed with little damage to structures other than the forelegs. In the present experiments all the blood was removed that could be with gentle pressure. Although the forelegs are important bearers of contact chemoreceptors, the other two pairs of legs, when stimulated, can produce proboscis extension[5]. If a uniform population of flies was desiccated until some became responsive to water, most of the remainder were made positive by bleeding (45 out of 53). The result was dramatic: as quickly as the fly could be tested after bleeding (a few seconds), a vigorous response was obtained when before there was none. Even when the bleeding was deliberately traumatic, a feeble response could be obtained as the animal died. In flies that were originally water-positive, bleeding did not alter the response (12 out of 12). The amount of blood obtainable seemed markedly less in the positive than in the negative flies; and it seemed that the few flies that did not respond after bleeding were those from which the greatest volume could be obtained. Apparently, if blood volume was above a certain level, bleeding could not reduce it sufficiently below some threshold value. Similarly, when members of a population were bled that had been given water to repletion, few were made water positive (4 out of 13).

These results do not conflict with Bolwig's[2], since blood osmotic pressure may well be a function of body water and blood volume. The results, however, demonstrate that neither osmotic concentration nor the concentration of any blood constituent determines sensitivity to water. Moreover, they do strongly suggest that blood volume via a rapid acting (neural) pathway sets the sensitivity of some element involved in the feeding response. Since some aspect of blood volume is the effective agent, the detector is most likely a mechanoreceptor. Although dehydration of the chemoreceptors as the mechanism cannot account for the present results, Wolbarsht's[3] suggestion that chemoreceptor sensitivity is the regulated factor is tenable. This might operate in two ways: either the chemoreceptors (one or both) are also affected by mechanical stimuli and some aspect of blood volume

is an effective mechanical stimulus, or mechanoreceptors elsewhere influence chemoreceptor discharge. Neither of these possibilities is unprecedented: Hodgson and Barton Browne[6] have evidence that bending of a chemosensory hair does alter (not very predictably) the response of the chemosensory cells to chemicals; and there are many demonstrations of the control of sense organ discharge by afferent neurones of the central nervous system[7]. However, histological[8] and electron microscopic (Dethier, V. G., personal communication) studies have not revealed nerve terminals on the chemosensory cells. The equally likely possibility remains that the mechanoreceptor discharge sets the sensitivity of some element further along the path of the feeding response. This latter mechanism has been shown to be the case for the regulation of taste thresholds to sugars[1]: sugar solutions in the foregut via an unknown connexion (neural or hormonal) with the central nervous system determine the behavioural sensitivity of the fly to sugars. Since all evidence indicates that the ingestion of both water and sugars is evoked by discharge of the same chemosensory cell[9], only a specific regulation of sensitivity to water at the level of the sensory cell would appear at first sight to provide for an independent regulation of water and sugar ingestion; but as will be shown elsewhere, this is not necessarily so[6]. There is evidence that the two are independently controlled (Dethier, V. G., personal communication). Additional details of the present experiments and other data relevant to the regulation of water ingestion will be reported elsewhere[6].

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VIROLOGY

Multiplication *in vitro* of a Nuclear Polyhedrosis Virus in Insect Amœbocytes

Culture, *in vitro*, of nuclear polyhedrosis virus has been achieved, so far, in cells derived from what appears to be the outer epithelial sheath of the larval ovariole of Lepidoptera[1,2]. Grace[3] reported virus induction *in vitro* in cells from explants of the same organ.

A method for the preparation of primary monolayers, using the usually abundant supply of larval haemocytes of one easily mass-reared species of Lepidoptera, *Peridroma saucia* (Hübner), is being described elsewhere[4]. Our interest in this type of cells for virological work was stimulated by the encouraging results obtained with similar cultures from vertebrate leukocytes[5]. Furthermore, it is not improbable, according to Wigglesworth[6], that the cells migrating from the explants of the larval ovariole maintained *in vitro* are haemocytes formerly adherent to the tissues.

Glaser[7] attempted infection, *in vitro*, of haemocytes from larvæ of *Malacosoma americanum* (Fabricius), with nuclear polyhedrosis virus. The results were negative. Formation of the typical intranuclear inclusions was observed by Glaser only when infection of the haemocytes occurred *in vivo*, and the cells transplanted *in vitro*, 10–12 days following infection of the animal. The lack of success in Glaser's infection experiment could have been derived from a lack of virus adsorption, or more likely from inactivation of the labile Berkefeld filtrate or from its preparation at a time when filterable elements were extremely rare in the larvæ used. Glaser's hypothesis that "... the early stages of the virus require some particular organ or tissue or some particular condition" is not supported, in part at least, by our investigations, as we have achieved direct infection of amœbocytes *in vitro*, in the particular microenvironment of our cell cultures.

The haemocytes of sixth-instar larvæ of *P. saucia* are cultured on Corning 22 × 22 mm. No. 1 cover glasses, in 60-mm. Petri dishes, with 4 ml. of medium[4] containing 15 per cent homologous insect blood plasma and 15 per cent fœtal bovine serum. After 20–24 hr. incubation at 25° C. in a gas mixture of 1 per cent oxygen, 3 per cent carbon dioxide and 96 per cent nitrogen, a continuous monolayer of single cells and polynucleated syncytia is formed (Fig. 1). The culture medium is discarded and the cells are rinsed with 3·5–4 ml. of a balanced salt solution[4]. The virus suspension is prepared as follows: Larvæ of *P. saucia* showing the definite syndrome of nuclear polyhedrosis are anæsthetized at the seventh day after peroral infection; their integument is cut laterally, along a longitudinal line, and the intestinal tract, with the Malpighian tubules, is excised and discarded. The remaining parts of the larvæ are placed immediately

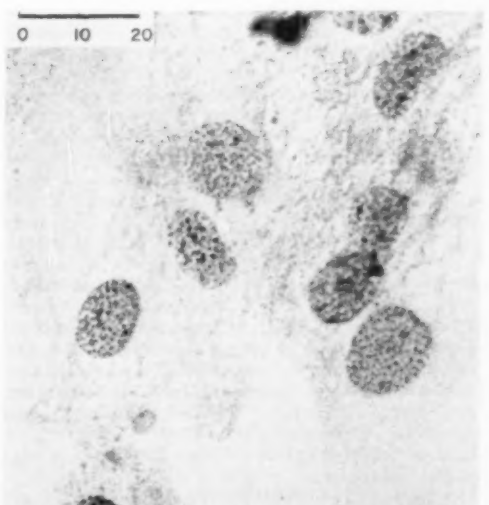

Fig. 1. Average field from a non-infected control culture of the same cell pool as in Fig. 2. Note the basophile granulations in the nuclei, which are typical for normal larval amœbocytes of *Peridroma saucia* (Hübner) *in vitro*. Culture, 6 days old, Duboscq-Brasil. Giemsa. Scale, microns

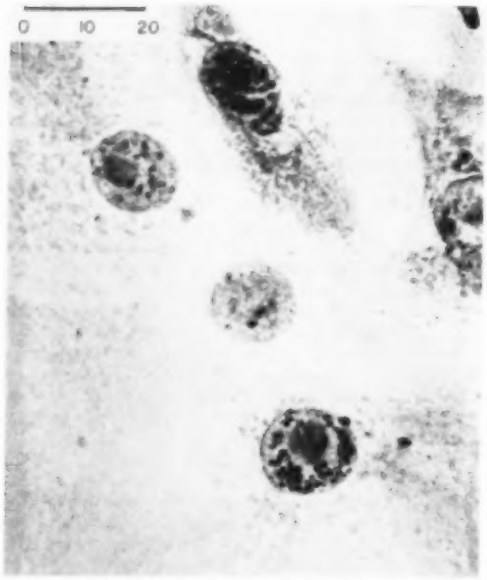

Fig. 2. A group of infected amœbocytes with nuclear polyhedra in an advanced stage of development. The central chromatin mass is still visible in two nuclei. Same cell pool as in Fig. 1. Culture, 6 days old. Infection, 5 days old. Duboscq-Brasil. Giemsa. Scale, microns. (Photography: V. G. Duran)

in a Ten Broek tissue grinder, with 2·5–5 ml. of culture medium[4] per larva. After homogenization, the fluid is centrifuged for 5 min. at maximum speed (3,200 r.p.m.) in the horizontal swinging tube head of an International clinical centrifuge, in order to eliminate the larger tissue particles and the polyhedral inclusion bodies. The supernatant is transferred to cellulose nitrate tubes and centrifuged for 10 min. at 10,000 r.p.m. in the angle rotor of a Servall *SS* 1 Superspeed centrifuge. The final supernatant is passed through a 'Millipore' microfibre glass prefilter disk and a 'Millipore' *HA* filter (pore size 450 mμ). The cultures are incubated with the virus suspension (0·5–2·0 ml.) for 3–4 hr., at 25° C. in the gas mixture described here. After this period the cultures are rinsed with balanced salt solution and supplied with 3·5–4 ml. of fresh culture medium, to which 30 per cent fœtal bovine serum has been added. On the third day after infection the medium is changed and at the fourth to sixth day after infection the cultures are fixed. The cover glasses are rinsed with balanced salt solution in a small Coplin staining dish, for about 5 min.; the balanced salt solution is replaced with Duboscq–Brasil's fluid (12 hr.), the slides are rinsed in repeated changes of 70 per cent ethanol and stained overnight in a 1 per cent solution of Giemsa's stain in *M*/112 phosphate buffer, at *p*H 7·17. Differentiation is performed in 80 per cent ethanol containing 0·5 per cent glacial acetic acid. The preparations are dehydrated in acetone–xylene mixtures and mounted in 'Caedax' Bayer.

Infection with nuclear polyhedrosis virus *in vitro* produced the typical sequence of cytological changes observed *in vivo*[5]. The cytopathogenic effect is particularly evident in the large, flattened nuclei of the amœbocytes (plasmatocytes), with a loss of basophilia, central condensation of the chromatin mass, formation of the 'anneau miroitant', and formation of the polyhedral inclusion bodies within the nucleus. In our preparations, most polyhedra were fixed and stained during their forming phase, when residues of the central chromatin mass were still visible; at this stage (Fig. 2) the inclusions are strongly eosinophile, and the infected cells can be spotted easily in the monolayer cultures by the bright red colour of the inclusion bodies, even at low magnification. These infected cells sometimes appear in groups, suggesting a possible use of these primary monolayers for virus titration *in vitro* by the plaque technique. Quantitative work on viral multiplication in our cell cultures is in progress.

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GENETICS

Effects of Maternal Age on the Incidence of Congenital Abnormalities in Mouse and Man

The value of data from laboratory animals for the interpretation of the incidence of congenital abnormalities in human beings was first pointed out some time ago by Wright[1]. Results I have obtained from a balanced two-point backcross linkage experiment in the mouse have shown an effect of maternal age both on viability and recombination. The purpose of this communication is to present these results and discuss their implications for similar phenomena in human beings.

The factors used in the linkage experiment were *pallid* and *fidget*; they are both recessives and known to be in linkage group V. Both factors are generally associated with fairly severe reductions in viability and fertility. The results were obtained from female coupling and repulsion heterozygotes using *pallid fidget* males. A summary of the results, analysed according to the age of the maternal parent, is given in Table 1. Following Fisher[2], the regression of the proportions of *fidgets*, *pallids* and recombinants with maternal age was analysed after applying the angular transformation. A more detailed analysis of these data will be published elsewhere.

The linear regression in the proportion of *fidgets* with maternal age is highly significant and the quadratic regression is significant at the 5 per cent level. The proportion of *pallids*, on the other hand, shows no significant linear regression but a highly significant quadratic component. It seems worth noting that the deterioration in *fidget* viability apparently starts before the major decrease in litter size.

The linear regression of recombination fraction with increasing maternal age is significant at the 5 per cent level and there is no evidence for any significant departure from linearity. A significant downward

Table 1. DATA FROM FEMALE HETEROZYGOTES TABULATED ACCORDING TO THE AGE OF THE MATERNAL PARENT

Age (months)	Total number of mice	No. of litters	*Fidgets* (per cent)	*Pallids* (per cent)	Recombinants (per cent)
2	115	21	38·3	32·2	32·2
3	84	19	53·6	41·7	30·9
4	106	17	42·5	42·5	24·5
5	98	18	35·7	37·8	28·6
6	108	17	36·1	48·2	34·3
7	73	15	42·5	47·9	23·3
8	92	19	34·8	39·1	23·9
9–10	80	20	27·5	41·2	22·5
11 and over	40	17	18·4	28·6	20·4

		Fidgets	*Pallids*	Recombinants
Linear regression	χ^2_1	13·77 *	0·23	4·08†
Quadratic regression§	χ^2_1	4·20†	8·10‡	0·18
Residual	χ^2_4	6·00	3·01	4·47

*, $P < 0{\cdot}1$ per cent. †, 5 per cent $> P > 1$ per cent. ‡, 0·5 per cent $> P > 0{\cdot}1$ per cent. § Approximate test giving equal weight to observations from different age groups.

trend of recombination with maternal age in mice was also reported by Fisher[2]. The phenomenon is well known in *Drosophila*[3].

Mongolism in man is now known to be caused by aneuploidy for one of the smaller somatic chromosomes[4]. This is most probably the result of meiotic non-disjunction for the relevant chromosome. Mongolism is also well known to increase in incidence with maternal age[5]. Early work with *Drosophila* showed that an increase of non-disjunction was generally associated with a decrease in crossing-over[6]. Thus the increase in the incidence of mongolism in man, reflecting an increase in non-disjunction, and the decrease in the frequency of recombination in mice may well have a common origin in the effect of maternal age on the efficiency of chromosome pairing at meiosis. In rye, Rees and Naylor[7] have shown that developmental variations within an anther cause significant differences in chiasma frequency. Chiasma formation and chromosome pairing may clearly be considerably affected by developmental differences such as probably occur in the ovum of the ageing mother. In fact Polani *et al.*[8] have suggested a specific mechanism for the way in which this might happen.

The effects of maternal age and order of birth on a number of developmental abnormalities in humans have been extensively studied (see, for example, Penrose[9]). The incidence of congenital deformities of the nervous system, in particular anencephaly, spina bifida and hydrocephaly, shows, in general, a marked increase with increasing maternal age. These are abnormalities which cannot be explained by any simple genetic hypothesis and which are considerably subject to environmental influences, as is well illustrated by Edwards's remarkable results[10]. An increase in the frequency of white spotting in guinea-pigs was also found by Wright[1]. It is in marked contrast to the decrease in the number of *fidgets*, and later *pallids*, with increasing maternal age in mice. In general it seems unlikely that any congenital abnormality associated with a single gene difference should show an increase in incidence with maternal age. Such a factor is likely to be associated with fairly severe viability disturbances, although perhaps not so severe as in mice because of the lack of intra-uterine competition. However, a decrease in incidence with maternal age certainly does not necessarily imply a simple genetic basis. Thus it has been shown in guinea pigs[1] and in mice[11] that the incidence of polydactyly decreases with maternal age. In both cases the variation was probably basically non-genetical developmental variation. It is, perhaps, surprising that it did not follow the same course as the developmental congenital abnormalities in humans.

Just as studies in mice may help in interpreting human phenomena, results from work on human beings may also be of relevance to the interpretation of mouse data. For example, Karn and Penrose[12] showed that birth-weight increases with parity and that birth-weights somewhat less than the maximum were most favourable to survival. Probability of survival, therefore, showed parabolic variation with parity. It is interesting that *pallid* viability, and probably also *fidget* viability, show similar parabolic variation with maternal age. No attempt has been made to separate the effects of maternal age and parity in these results; but the two are clearly highly correlated. Certainly *fidget*, and to a lesser extent *pallid*, reduce birth weight so that an initial increase in birth weight may well account for their initial increase in viability.

An initial decrease in the incidence of spina bifida and hydrocephalus with increasing maternal age in human beings was found by Edwards[10]. This may well reflect a similar phenomenon to the initial increase in *pallid* and *fidget* viabilities in the mice.

The parallelism between effects on the incidence of congenital abnormalities in mouse and man, which is illustrated by the above data, serves to emphasize the mutual benefits to be derived from workers on either organism studying each other's results.

I am grateful to Prof. K. Mather for directing my attention to the relationship between non-disjunction and crossing-over.

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Variation in the Behaviour of Different Genotypes of *Drosophila* towards Odoriferous Vegetable Oils

Drosophila are repelled by certain odours; the repulsion from medium containing peppermint oil shown by adult flies can be converted into an attraction towards such food by exposing the individuals as larvæ or adults to the odour[1]. It might therefore be expected in a population exposed to two or more odours, for example, food plants, that part of the population could become specifically adapted to one and part to the alternative odour. Disruptive selection of this type could well give rise to polymorphism[2] or even biological races, and the work reported here was part of an attempt[3] to produce divergence within populations by such means, though Thoday[4] and others have already demonstrated experimentally the production of polymorphism as an outcome of artificial disruptive selection.

About forty etherized *D. melanogaster* were placed in a tube connecting two half-pint milk bottles. In

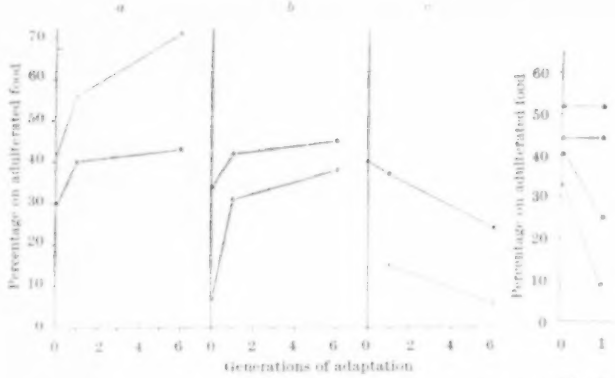

Fig. 1

Fig. 2

Fig. 1. Response of Dronfield flies given a choice of normal food and food containing (*a*) 2 per cent peppermint oil; (*b*) 7 per cent juniper oil; (*c*) 3·5 per cent lavender oil. Solid symbols, flies; open symbols, eggs laid. Each point based on at least eight replicates

Fig. 2. Response of two mutant stocks when given a choice of normal food and food containing 3·5 per cent lavender oil. Solid symbols, flies; open symbols, eggs laid; squares, *th st cp*; triangles, *se cp e*. Each point based on at least ten replicates

one bottle was a spoon with food containing an adulterant, in the other was a spoon with normal food. The number of flies in each bottle was recorded after 1 hr. and after 24 hr., at which time the numbers of eggs laid were also scored. Flies were adapted by mass culture in bottles with adulterated food. Where more than one generation of adaptation took place, flies were transferred to new cultures at intervals of twenty days.

Fig. 1 shows the response of unadapted flies, one-generation adapted flies and six-generation adapted flies of a wild-type stock (Dronfield) presented with a choice of normal and adulterated food, for three adulterants. The black points represent the mean number of flies in the bottle with adulterated food (mean of two counts) as a percentage of the total. The circles represent the mean number of eggs laid on the adulterated food as a percentage of the total.

The response to food containing 2 per cent peppermint essence (Fig. 1*a*) is clearly one of increasing attraction with increasing adaptation. After six generations of adaptation to peppermint food, flies choose to lay eggs on this, rather than on normal, food; though as individuals they do not show so marked a preference for remaining on the adulterated food. Fig. 1*b* shows comparable data for food containing 7 per cent juniper oil, and clearly the pattern of response, both of flies and egg laying, is similar to that found with peppermint food. By contrast, flies reared on food containing 3·5 per cent lavender oil are more repelled by such food than are flies reared normally (Fig. 1*c*). The proportion of eggs laid on adulterated food by six-generation adapted flies is less than the proportion laid by one-generation adapted flies. Comparable egg-laying data for unadapted flies are unfortunately not available because of culture failures.

Two mutant genotypes $\frac{th\ st\ cp}{th\ st\ cp}$ and $\frac{se\ cp\ e}{se\ cp\ e}$ tested as unadapted and one-generation adapted flies with food containing lavender oil produced results shown in Fig. 2. The *th st cp* stock resembles the Dronfield stock in that adaptation increases the repulsion of the adulterated food for the flies. The behaviour of the *se cp e* flies is unaffected by rearing on food containing lavender.

In two strains adaptation to food containing lavender oil produces increasing repulsion from such food, and we do not know whether these behavioural changes are the result of physiological conditioning[3], natural selection, or both processes. It seems highly unlikely that only the conditioning process is involved, for considerable mortality was observed in the adapting cultures, and the stocks of *Drosophila* used are known to be genetically heterogeneous. The adaptation (*sensu* biological efficiency) of the populations to lavender food after six generations of exposure to such food must be greater than the initial level of adaptation and therefore adaptation to, and preference towards, lavender food are negatively correlated. Lavender oil essence is toxic, and a behavioural tendency to avoid it, when a choice of food with and without it is presented, probably confers selective advantage in such an environment.

It is unlikely that the distribution of lavender oil in the culture bottles was heterogeneous, for the oil in solution was mixed into the food whereas the latter was liquid. Thus the increased repulsion with adaptation demands that relative ability to survive on lavender food and relative distaste for this food are effects either of pleiotropy or of rather closely linked genes. Whatever the mechanism controlling the behaviour, it is clear that genetic variation for it exists within the species.

The only other example of a similar situation which we have been able to find is that described for *Leptinotarsa* (Colorado beetle) fed on various species of *Solanum*[6]. After feeding on potato, larvæ and male adults preferred horsenettle to this plant. After feeding on horsenettle all individuals preferred potato to this, and after feeds on bitter nightshade this was rejected for horsenettle. Clearly only a conditioning process and not natural selection is involved here.

In any biological population in which this phenomenon of adaptation producing relative distaste occurred, the chances of evolutionary advance to the formation of a biological race via disruptive selection would be minimal, but the population might retain a greater range of exploitable habitat and hence greater versatility. Nevertheless since, as our results show, genetic variance for this character is available in the species, it is possible that some populations could produce polymorphic systems based on behavioural differences.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, June 19

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting.

Monday, June 19—Tuesday, June 20

PLASTICS INSTITUTE (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 9.30 a.m. daily.—Conference on "Education and Training in the Plastics Industry".

Monday, June 19—Thursday, June 22

LABORATORY APPARATUS AND MATERIALS EXHIBITION (at the Royal Horticultural Society's New Hall, Westminster, London, S.W.1).

Tuesday, June 20

OLIVER BIRD TRUST, and the SOCIETY FOR THE STUDY OF FERTILITY (in the Large Lecture Theatre, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5 p.m.—Dr. A. S. Parkes, F.R.S.: "The Biological Control of Conception" (Fifth Oliver Bird Lecture).

Wednesday, June 21

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. D. Tyrrell: "Some Recent Experiments on the Common Cold Problem".*

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

SOCIETY FOR ANALYTICAL CHEMISTRY, MICROCHEMISTRY GROUP (at "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion Meeting on "Quantitative Paper Chromatography" introduced by Mr. E. C. Hunt and Dr. D. Gross.

Thursday, June 22

BIRKBECK COLLEGE (in the Large Physics Theatre, Malet Street, London, W.C.1), at 4.15 p.m.—Prof. H. Zocher (Ministry of Agriculture, Rio de Janeiro): "Spontaneous Orientation in Suspensions of Macromolecules and Phase Particles".*

Friday, June 23

UNIVERSITY OF LONDON (in the Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Riccardo Passerini (University of Catania): "Refining Processes and Petrochemical Raw Material Sources".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER (with special qualifications in pure mathematics) IN MATHEMATICS (Grade I or II)—The Registrar (Room 22, O.R.B.), The University, Reading (June 21).

LECTURER OR ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Registrar, The University, Liverpool (June 23).

ASSISTANT LECTURER, Grade B (with a good honours degree in chemistry or an equivalent high qualification, and preferably a higher degree) IN THE DEPARTMENT OF CHEMISTRY AND BIOLOGY, to assist with teaching in Higher National Certificate and Graduate R.I.C. courses with special reference to inorganic and analytical chemistry —The Registrar, Welsh College of Advanced Technology, Cathays Park, Cardiff (June 24).

SCIENTIFIC OFFICER OR SENIOR SCIENTIFIC OFFICER (graduate, experienced in agricultural research), to assist the Head of the Field Experiments Section—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (June 24).

ASSISTANT LECTURER OR LECTURER (with special qualifications in geometry) IN MATHEMATICS—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (June 26).

CHAIR OF BACTERIOLOGY—The Registrar, The University, Manchester 13 (June 30).

DEMONSTRATOR IN GEOGRAPHY—The Registrar, University College of North Staffordshire, Keele, Staffs (June 30).

RESEARCH ASSISTANT (honours graduate (or prospective graduate this summer) in botany or agricultural botany) IN AGRICULTURAL BOTANY in the Department of Agricultural Sciences, School of Agriculture, Sutton Bonington, to carry out ecological and genetic studies on natural hybrids between ryegrass and meadow fescue—The Registrar, The University, Nottingham (June 30).

RESEARCH FELLOW (with research experience in biochemistry or chemistry and interest in physico-chemical aspects of biochemistry) IN PHYSICAL BIOCHEMISTRY at the John Curtin School of Medical Research, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

SCIENTIFIC OFFICER OR SENIOR SCIENTIFIC OFFICER (with research experience in enzymology and/or protein chemistry, and some knowledge of, and interest in, fundamental genetic problems), to work on biochemical aspects of genetics—The Secretary, John Innes Institute, Bayfordbury, Hertford, Herts (June 30).

ASSISTANT LECTURER, and a LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, University College, Singleton Park, Swansea (July 1).

LECTURER or ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Sheffield (July 1).

LECTURER (preferably with a Ph.D. or equivalent experience in metallurgy, or in pure science if interest and experience are related to metals) IN METALLURGY—The Registrar, The University, Sheffield (July 1).

CHAIR OF CHEMICAL PATHOLOGY in the University College, Ibadan, Nigeria—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (July 3).

LECTURER or ASSISTANT LECTURER (botanist, with special experience in the taxonomy, morphology or genetics of horticultural plants) IN THE DEPARTMENT OF AGRICULTURAL BOTANY—The Registrar (Room 22, O.R.B.), The University, Reading (July 3).

LECTURER IN ZOOLOGY—The Secretary, The University, Aberdeen (July 6).

LECTURER (preferably qualified to teach ancient philosophy or the philosophy of science) IN LOGIC—The Secretary of University Court, The University, Glasgow (July 8).

RESEARCH STUDENT (with a good honours degree including chemistry) IN CHEMISTRY, to read for a higher degree working on problems related to cationic polymerization under Dr. P. H. Plesch—The Registrar, University College of North Staffordshire, Keele, Staffs (July 8).

SENIOR LECTURER OR LECTURER IN HÆMATOLOGY IN THE DEPARTMENT OF PATHOLOGY, University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (July 8).

PROFESSOR OF PHILOSOPHY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 15).

RESEARCH STUDENT (with an honours degree or equivalent qualification) IN ELECTRODIALYSIS—Prof. G. M. Burnett, Department of Chemistry, The University, Aberdeen (July 15).

LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, The University, Aberdeen (July 18).

LECTURER IN PSYCHOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 28).

CHAIR OF CHEMISTRY in the University of Cape Town, South Africa —The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, July 30).

SENIOR LECTURER IN PHYSIOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London July 30).

LECTURER (preferably with experience in teaching, research and the design and construction of hydraulics works and apparatus) IN CIVIL ENGINEERING (HYDRAULICS) at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 4).

ASSISTANT EXPERIMENTAL OFFICER (with experience in analytical chemistry), to work on protein and carbohydrate metabolism—The Secretary, Rowett Research Institute, Bucksburn, Aberdeen.

ASSISTANT, Grade B (male), TO TEACH CHEMISTRY, PHYSICS AND SOME MATHEMATICS to Ordinary level G.C.E. standard—The Principal, North-West Kent College of Technology, Miskin Road, Dartford, Kent.

ASSISTANT LECTURER (preferably with an interest in fuel technology) IN THE DEPARTMENT OF CHEMICAL TECHNOLOGY—The Secretary, The Royal College of Science and Technology, George Street, Glasgow.

LABORATORY TECHNICIAN (preferably with biochemical experience, and A.I.M.L.T. or equivalent), for the Neonatal Unit at the Hammersmith Hospital, Ducane Road, London, W.12—The Secretary, Institute of Child Health, The Hospital for Sick Children, Great Ormond Street, London, W.C.1.

LECTURER (preferably with a higher degree and research experience in an industrial environment) IN METALLURGY in the Department of Materials, to lecture at postgraduate level on the fundamental metallurgical aspects of technological processes—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

MASTER TO TEACH PHYSICS—The Headmaster, Plymouth College, Plymouth, Devon.

READER (with a higher degree in electrical engineering and adequate research experience) IN ELECTRICAL ENGINEERING; and a PRINCIPAL LECTURER (with a good honours degree in electrical engineering and practical experience in the electrical industry) IN ELECTRONICS—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

RESEARCH ASSISTANT (preferably with a medical qualification) IN THE CLINICAL BACTERIOLOGY LABORATORY—The Administrator and Secretary, University College Hospital, Gower Street, London, W.C.1.

RESEARCH ASSISTANT (science graduate, with an interest in either biology or chemistry), for duties concerned with the investigation of immunological problems—The Regional Director, Blood Transfusion Service, Law Hospital, Carluke, Lanarkshire.

SCIENTIFIC OFFICER OR SENIOR SCIENTIFIC OFFICER (suitably qualified honours graduate) IN THE BACTERIOLOGY DEPARTMENT, for work concerned with microbiology of the rumen—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 61/17.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Institute of Seaweed Research, Inveresk. Annual Report for 1960. Pp. 23. (Inveresk, Midlothian: Institute for Seaweed Research, 1961.) [44

The Scottish Field Studies Association. Annual Report, 1960. The Importance of Field Studies in Modern Education. By Paul F. Holmes. Garth House as a Centre for Ecological Botany. By Fred N. and Brenda D. Haynes. Pp. 27 + 4 plates. (Glasgow: Scottish Field Studies Association, 1961.) 2s. 6d. [44

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Royal Greenwich Observatory Bulletins, No. 20: Time Service 1959, October–December. Pp. B277–B292. 3s. 6d. net. No. 22: Time Service 1960, January–March. Pp. B1–B20. 3s. 6d. net. No. 23: Measurements of Radial Velocity from Conde Plates. By R. v.d. R. Woolley, D. H. P. Jones and Linda M. Mather. Pp. E1–E25. 4s. net. (London: H.M. Stationery Office, 1960.) [74

Ministry of Health: and General Register Office. Report on Hospital In-Patient Enquiry for the two years 1956–1957. Pp. vii + 355. (London: H.M. Stationery Office, 1961.) 18s. net. [74

Royal Greenwich Observatory Bulletins, No. 17: Magnetic Results 1956 (Abinger). Pp. D1–D242. (London: H.M. Stationery Office, 1960.) 63s. net. [74

Other Countries

Smithsonian Institution, Washington: Contributions from the Museum of History and Technology: Paper 12: Hermann Stieffel, Soldier-Artist of the West. By Edgar M. Howell. Pp. 1–16. Paper 13: North Devon Pottery and Its Export to America in the 17th Century. By C. Malcolm Watkins. Pp. 17–56. 35 cents. Paper 14: Tea Drinking in 18th Century America—Its Etiquette and Equipage. By R. Roth. Pp. 61–91. 40 cents. Paper 15: Italian Harpsichord Building in the 16th and 17th Centuries. By John D. Shortridge. Pp. 93–107. 20 cents. Paper 19: Elevator Systems of the Eiffel Tower, 1889. By Robert W. Vogel. Pp. 1–40. Paper 20: John Eriesson and the Age of Caloric. Pp. 41–80. 15 cents. (Washington, D.C.: Government Printing Office, 1960 and 1961.) [283

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United States Department of the Interior: Geological Survey. Bulletin No. 1116-C: Geophysical Abstracts, 182, July–September, 1960. By James W. Clarke, Dorothy B. Vitaliano, Virginia S. Neuschel and others. Pp. iii + 281–455. 40 cents. Water-Supply Paper 1537: Ground-Water Levels in the United States, 1956–57, Northeastern States. Prepared under the direction of Philip E. LaMoreaux. Pp. v + 144. 55 cents. Professional Paper 354-F: Zones and Zonal Variations in Welded Ash Flows. By Robert L. Smith. Pp. iii + 149–158 + plates 20 and 21. (Washington, D.C.: Government Printing Office, 1960.) [283

United States Department of the Interior: Geological Survey. Bulletin 1071-F: Corals from Well Cores of Madison Group, Williston Basin. By William J. Sando. Pp. iii + 157–190 + plates 13–20. 1 dollar. Bulletin 1081-C: Geology of the Maddux Quadrangle, Bearpaw Mountains, Blaine County, Montana. By Brice Bryant, Robert G. Schmidt, and W. T. Pecora. Pp. iii + 91–116 + plate 3. Bulletin 1082-F: Geology and Fluorspar Deposits, Northgate District, Colorado. By Thomas A. Steven. Pp. v + 323–422 + plates 12–17. Bulletin 1083-E: Anomalous Remanent Magnetization of Basalt. By Allan Cox. Pp. iv + 121–160. 20 cents. Bulletin 1111-C, D: Petrology of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation at Coal Canyon, Wyoming. By R. A. Gulbrandsen. A Method of X-ray Analysis for Determining the Ratio of Calcite to Dolomite in Mineral Mixtures. By R. A. Gulbrandsen. Pp. x + 71–152 + plates 29–33. (Washington, D.C.: Government Printing Office, 1960.) [44

United States Department of the Interior: Geological Survey. Water-Supply Paper 1625: Surface Water Supply of the United States, 1959. Part 3-A: Ohio River Basin Except Cumberland and Tennessee River Basins. Prepared under the direction of J. V. B. Wells. Pp. xii + 565. 1.75 dollars. Water-Supply Paper 1627: Surface Water Supply of the United States, 1959. Part 4: St. Lawrence River Basin. Prepared under the direction of J. V. B. Wells. Pp. x + 417. Water-Supply Paper 1628: Surface Water Supply of the United States, 1959. Part 5: Hudson Bay and Upper Mississippi River Basins. Prepared under the direction of J. V. B. Wells. Pp. xii + 562. 1.75 dollars. Water-Supply Paper 1631: Surface Water Supply of the United States, 1959. Part 7: Lower Mississippi River Basin. Prepared under the direction of J. V. B. Wells. Pp. xii + 559. (Washington, D.C.: Government Printing Office, 1960 and 1961.) [44

United States Department of the Interior: Geological Survey. Professional Paper 282-F: Drainage Basins, Channels, and Flow Characteristics of Selected Streams in Central Pennsylvania. By Lucien M. Brush, Jr. Pp. iv + 145–181 + plates 5–7. Professional Paper 326: Cenozoic History of Northeastern Montana and Northwestern North Dakota with emphasis on the Pleistocene. By Arthur David Howard. Pp. v + 107 + 8 plates. Professional Paper 328: Geology of the Yankton Area, South Dakota and Nebraska. By Howard E. Simpson. Pp. v + 124 (13 plates). Professional Paper 331-A: Archeogastropoda, Mesogastropoda and Stratigraphy of the Ripley Owl Creek and Prairie Bluff Formations. By Norman F. Sohl. Pp. iv + 151 + 18 plates. 2 dollars. Professional Paper 356-B: Uranium and other Trace Elements in Petroleums and Rock Asphalts. By Kenneth G. Bell. Pp. iii + 45–65. 1 dollar. (Washington, D.C.: Government Printing Office, 1960 and 1961.) [44

East Africa High Commission. Annual Report of the East African Council for Medical Research, 1959/1960. Pp. ii + 15. (Nairobi: Government Printer, 1960.) 2s. [44

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Research Council of Alberta. Preliminary Report 61-1: The Clover Bar Coal Zone, Edmonton–Morinville District, Alberta. By G. Raymond Pearson. Pp. iii + 26. (Edmonton: Research Council of Alberta, 1961.) 50 cents. [44

United States Department of Commerce: National Bureau of Standards. Handbook No. 76: Medical X-ray Protection up to Three Million Volts. (Recommendations of the National Committee on Radiation Protection and Measurements. N.C.R.P. Report No. 26.) Pp. viii + 52. (Washington, D.C.: Government Printing Office, 1961.) 25 cents. [44

Canada: Department of Mines and Technical Surveys, Geological Survey of Canada. Bulletin 65: A Late Silurian Fauna from the Sutherland River Formation, Devon Island, Canadian Arctic Archipelago. By Arthur J. Boucot, Anders Martinsson, R. Thorsteinsson, Otto H. Wallser, H. B. Whittington and Ellis Yochelson. Pp. iv + 51 + 10 plates. 1.25 dollars. Paper 60-12: Geological Observations in Northern New Quebec, 34 and 35 (parts of). By Ralph Kretz. Pp. iii + 17 + map 13. 50 cents. Paper 61-1: Summary: Account of Carboniferous and Permian Formations, Southwestern District of Mackenzie. By P. Harker. Pp. i + 9. 25 cents. (Ottawa: Queen's Printer, 1960 and 1961.) [44

United States Department of Commerce: National Bureau of Standards. Handbook No. 78: Report of the International Commission on Radiological Units and Measurements (I.C.R.U.), 1959. Pp. x + 90. (Washington, D.C.: Government Printing Office, 1961.) 65 cents. [44

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Animal Feeding Stuffs

Animal husbandry in its beginnings may well represent one of mankind's first faltering steps towards a civilised existence; it is certainly vital now to his continued existence. It is practised still—for the most part—in the pastoral atmosphere that has characterised it for centuries, but the scientific skills of civilisation have gradually modified the practice from one of mere selection and adaptation to environment to one fully cognisant of nutritional requirements. The farming year may be controlled by season and weather, but the health and vigour of the farmer's stock are becoming increasingly independent of them.

The feeding stuffs industry has contributed significantly to this during the last few decades. From the first simple approach that pressed protein residue—the by-product of the oil milling industry—would provide a useful supplement for stock feeding, it has developed to provide a range of balanced diets to suit all kinds of farm stock.

Unilever have been engaged in research into feeding stuffs ever since Lynn pioneered the first balanced ration for cattle, pigs and poultry, and the work has gained from collateral studies in human nutritional requirements, particularly of vitamins.

Today, research is being carried out mainly at Colworth House in Bedfordshire, and here Dow and his colleagues are engaged in a series of studies—Bellis on minerals and energy balance in pigs: Burt on ruminant metabolism in relation to calf-rearing: Thomson on factors affecting milk quality: and Pearson on protein utilisation by poultry. In collaboration with Hurst they are also studying the influences of bacteria on animal nutrition.

UNILEVER RESEARCH

UR 3-7043

APPOINTMENTS VACANT

BRISTOL COLLEGE OF SCIENCE AND TECHNOLOGY

Ashley Down, Bristol, 7

Owing to an internal promotion, the Governors invite applications for the following post in the SCHOOL OF PHARMACY

SENIOR LECTURER IN PHYSIOLOGY/PHARMACOLOGY

Candidates must be Honours Graduates in Pharmacy or possess a qualification of the Pharmaceutical Society and an appropriate Science Degree. Adequate teaching, industrial or research experience will be required as additional qualifications. The successful candidate will be required to organize the teaching of physiology and Pharmacology to pharmaceutical students and to candidates reading for the Diploma in Technology in Applied Biology. Research activities will be encouraged and appropriate facilities are available.

Salary within range £1,550 to £1,750. Scale at present under review.

The successful candidate will be expected to commence duties on, or as soon as possible after, September 1, 1961.

Details and forms of application from the Registrar. Please quote ref. CST 61/28.

DEPARTMENT OF CHEMISTRY AND BIOLOGY

RESEARCH STUDENTSHIPS

Applications invited for research studentships from candidates having a good honours degree or equivalent qualification, e.g., Grad.R.I.C.

Research is at present being carried out in the Department in the following fields:

Alkaloid chemistry, organic chemistry of fluorine, carbohydrates, synthetic nucleosides and nucleotides, thermo gravimetry, complex chemistry of cobalt, analytical chemistry of zinc, the effect of radiation on solids, radiochemical analysis, extractive distillation, gas chromatography, liquid vapour equilibria at high pressures, properties of sulphur trioxide, kinetics of fluorination processes, the ecology and physiology of lampreys and neuro-physiology.

The Department of Scientific and Industrial Research is prepared this year to offer suitable candidates a limited number of research studentships tenable at the Bristol College of Science and Technology. The value of these awards will be governed by their Regulations, and will be within range £270 to £540, depending on experience and arrangements for residence.

Inquiries and applications, for which there are no forms, to the Registrar, Bristol College of Science and Technology, Ashley Down, Bristol 7.

LONDON COUNTY COUNCIL

NORWOOD TECHNICAL COLLEGE

Knight's Hill, S.E.27

DEPARTMENT OF BIOLOGY AND GEOLOGY

Graduate Research Assistant required September, 1961; initially for period of two years, may be extended to three; to work in a team engaged on a survey of marine plankton. The material is supplied by the New Zealand Institute of Oceanography and forms part of their survey of Sub-Antarctic plankton. Person appointed will be encouraged to submit work for a higher degree. Allowance: £400 plus approximately £180 from six hours week visiting teaching which is obligatory.

Application forms from Principal, returnable in two weeks; enclose self-addressed foolscap envelope. Please quote (FE.3/N/1553/6).

ROAD RESEARCH LABORATORY (Traffic and Safety Division), Langley, Bucks., requires Senior Scientific Officers/Scientific Officers to carry out theoretical and experimental research on traffic flow and road safety, including psychological and statistical aspects, physics of friction and impact problems, theoretical problems on traffic and application of electronic computer to these problems. Qualifications, first- or second-class honours degree or equivalent for Scientific Officer, and similarly with appropriate postgraduate research experience for Senior Scientific Officer. Salary: Scientific Officer, £738 to £1,222; Senior Scientific Officer, £1,342 to £1,654. Good prospects for promotion to Principal Scientific Officer, salary scale, £1,716 to £2,418. Opportunities for early establishment with superannuation under age 31. Laboratory expects to move to Crowthorne, Bracknell, Berkshire in 1963.—Application forms from Director of Road Research, Road Research Laboratory, Harmondsworth, West Drayton, Middlesex (or 'phone Skyport 1421, Extn. 202), quoting ROAD 9YXW.

ICI

PLASTICS DIVISION

The rapid expansion of this Division, already the largest manufacturers of plastics materials in the Commonwealth, gives rise to vacancies for:

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IN OUR RESEARCH DEPARTMENT

We require men with good Honours degrees and Research experience, who are capable of creative thinking, for

(a) exploratory organic work aimed at the discovery of new polymers;

(b) Physico-chemical studies of polymerization reactions and the characterization of the products;

(c) development of new products and processes from the laboratory scale up to the production plant.

Pension and Profit-sharing Schemes are in operation and for married men temporary lodging allowances are available, and assistance is given towards house purchase and removal expenses.

Apply briefly to:

The Staff Manager,
Imperial Chemical Industries Limited,
Plastics Division,
Bessemer Road, Welwyn Garden City, Herts,
quoting reference No. 5122/Y.

UNIVERSITY OF CAPE TOWN

LECTURER IN GEOLOGY

Applications are invited for the post of Lecturer in the Department of Mineralogy and Geology. The salary scale is R.2,680 by R.120 to R.3,520 (£1,340 by £60 to £1,760) per annum. The information given by applicants should include age, a recent photograph, qualifications, experience, research work completed or in progress, and the names of at least two referees whom the University may consult. Reprints of published work should accompany the application.

Two copies of the application and testimonials should reach the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (from whom memoranda giving the general conditions of appointment, including transport expenses on appointment and information on the work of the department may be obtained), not later than July 31, 1961. An additional copy should be sent direct by airmail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa, to reach him by the same date. The University reserves the right to appoint a person other than one of the applicants or to make no appointment.

APPLICATIONS ARE INVITED FOR THE position of Assistant Professor of Biology with specialization in Limnobiology. Ph.D. standing or its equivalent from a recognized University is essential. Salary will be in the range $7,000 to $8,500, depending upon qualifications and experience. Appointment dates from July 1, 1962. Duties at the University commence not later than September 1, 1962, and include undergraduate teaching in general biology and a programme of research and graduate teaching in Limnobiology. Facilities in this field are excellent.—Applications, including curriculum vitae, names of referees, and a recent photograph, should be addressed to Head of Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

COUNTY BOROUGH OF STOCKPORT

Applications invited for following posts at Stockport College for Further Education: (1) Lecturer in Science Department to teach either Inorganic Chemistry or Physical Chemistry to the standard of Part I B.Sc. and G.M.R.I.C. Part I. Candidates must be honours graduates of a British university. (2) Graduate Assistant Lecturer, Grade "B" in the Department of General Studies to teach Physics and Mathematics to G.C.E. Standard. (3) Assistant Lecturer (Grade "B") in Mechanical Engineering Department to teach subjects in the Ordinary National Certificate courses. In each case, duties to commence on September 1, 1961, or as soon as possible thereafter. Burnham Technical Scale. Agreed conditions of tenure.

Application forms and further particulars from Principal, Stockport College for Further Education, Wellington Road South, Stockport, to be returned by June 26, 1961.

LONDON COUNTY COUNCIL

PADDINGTON TECHNICAL COLLEGE

SALTRAM CRESCENT, W.9

DEPARTMENT OF PHYSICS AND MATHEMATICS

Applications are invited for: (a) The post of Assistant Lecturer, Grade B, in Physics. The successful candidate will share in the teaching of "A" level classes and, possibly, in the teaching of Physics Laboratory Techniques to Laboratory technicians. (b) The post of Assistant Lecturer, Grade A, to teach Metalwork, the Use of Plastics and Technical Drawing, to students who are laboratory technicians. Salary: Grade B within range £738 to £1,201; Grade A, £558 to £1,051, with additions for qualifications and training. Point of entry dependent on experience.

Particulars and forms of application from the Secretary, returnable by June 24. Please quote (FE1a/N/1551/6).

JOHN LYSAGHT (AUSTRALIA) LIMITED

require

RESEARCH STAFF

CORROSION RESEARCH

A Research man with experience and specia training in corrosion. An immediate objective will be to extend existing knowledge of the under-water corrosion of zinc and galvanized iron, in terms of fundamental electrochemistry, and methods of protection, and to investigate the effects of aluminium and other elements in the zinc on atmospheric and under-water corrosion. The corrosion research will be part of a general approach to reactions at metal surfaces, extending a programme which has been in operation for some time. The appointment would be in the first place for three years to Lysaght's Central Research Laboratory at Newcastle Works. Travelling expenses would be paid, staff arrangements, superannuation, leave, etc., are good. The salary will be in the range £A.1,500 to £A.2,2[illegible] according to qualifications and experience.

METAL SURFACES RESEARCH

A Research man with prior experience to investigate metal surface phenomena related mainly to low carbon and silicon steel sheet and strip and galvanized iron. The initial approach will be fundamental but with a view to possible practical application in the fields of coatings, surface properties or reactions. It is hoped that duties will include supervision of a small group on corrosion research. The appointment would be in the first place for three years to Lysaght's Central Research Laboratory at Newcastle Works. Travelling expenses would be paid, staff arrangements, superannuation, leave, etc., are good. Salary in the range £A.1,800 to £A.2,500 depending on qualifications and experience.

The company produces about 700,000 tons of sheets per annum, and has an air conditioned, well equipped Central Research Laboratory with a staff of 20, and excellent Works Laboratories with a staff of over 100. Publication of results is encouraged.

If you are interested, please apply in writing to THE RESEARCH SUPERINTENDENT,
JOHN LYSAGHT (SERVICES) LIMITED, G.K.N. HOUSE, 22 KINGSWAY, LONDON, W.C.2
who will treat any application as confidential and provide any additional information.

SURREY EDUCATION COMMITTEE

KINGSTON TECHNICAL COLLEGE
FASSETT ROAD, KINGSTON-UPON-THAMES

Required September 1, 1961, or as soon thereafter as possible, Assistant Grade B in Mathematics, Department of Physics and Mathematics, and Assistant Grade B in Geology, Department of Chemistry, Biology and Geology. Candidates should be honours graduates, preferably with teaching or research experience. Salary, Burnham Technical Scale (now under review), Assistant Grade B £700 by £27 10s. (15) £37 10s. to £1,150, plus London allowance with appropriate allowances for degree, training and experience.

Application form and further particulars from Principal, to be returned as soon as possible.

MOUNT VERNON HOSPITAL

NORTHWOOD, MIDDLESEX

Technician required by Research Laboratory to assist in preparation of material for human chromosome studies. Opportunity to take part in research in this expanding field, with good prospects for suitable applicant. Salary dependent on qualifications.

Application, with full personal details and two names for reference, to Administrative Officer.

FORESTRY COMMISSION, ALICE HOLT Research Station, Farnham, Surrey: Scientific Officer (man or woman) for work on soils and nutrition of forest crops. Pensionable post for Physicist interested in biology or biologist interested in physics and instrumentation. Age: at least 21 and normally under 29 on December 31, 1961. Qualifications: normally a degree, or Dip. Tech., with first- or second-class honours, or equivalent. Final-year students may apply. Training in soil science not essential. Interim salary scale £717 to £1,186. Starting salary may be above minimum.—Application forms obtainable from Civil Service Commission, 17 North Audley Street, London, W.1, quoting S/52/61/AH. Applicants wishing to visit the Research Station, or obtain further particulars of its work, may write to the Chief Research Officer at Alice Holt Lodge.

COURTAULDS

Instrument Engineers or Physicists

COURTAULDS requires Instrument Engineers or Physicists for their Research and Development Organisation at Coventry.

Vacancies exist for suitably qualified men :

(1) To develop from first principles, analytical and other instruments based on original ideas.

(2) To join a Group providing a complete process control instrumentation service for the three major units of the Research and Development Organisation at Coventry.

Applicants, who should be under 35 years of age, should have a Ph.D. or a good honours Degree in Physics, Mechanical or Electrical Engineering. A flair for instrumentation, coupled with some experience in either the application of instruments and computers to the control of chemical and physical processes, or the design and development of instruments, is essential.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds Limited, 16 St. Martin's-le-Grand, London, E.C.1, quoting reference number D.93.

NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

Rutherford High Energy Laboratory

EXPERIMENTAL PHYSICISTS

The National Institute for Research in Nuclear Science was formed in 1958 to provide for the common use of Universities those large and expensive facilities which are nowadays required for nuclear research. In the Rutherford High Energy Laboratory situated near Harwell in Berkshire two accelerators are planned; a 50 MeV. proton linear accelerator which is already in operation, and a 7 GeV. proton synchrotron due for completion at the end of 1962. Applications are invited from suitably qualified persons for several research posts. These are fixed term appointments for periods up to five years and carry F.S.S.U. benefits.

DUTIES:

(*a*) To collaborate with teams of physicists engaged in designing a 7 GeV. proton synchrotron, and to take responsibility for aspects of selection, analysis and transport of high energy particle beams. The work will culminate in the use of these beams for high energy nuclear research, in which successful applicants will participate.

(*b*) To work with a team of nuclear physicists engaged in research using the 50 MeV. proton linear accelerator, and to collaborate with university physicists using this machine.

QUALIFICATIONS:

A first or upper second class honours degree in physics is required. Postgraduate experience in some aspect of nuclear physics is highly desirable.

SALARIES:

In one of the ranges £790–£1,310, £1,440–£1,770 (and exceptionally £1,840–£2,590) depending upon qualifications and experience, with possibilities for advancement during the period of employment. A higher minimum salary would apply to candidates with postgraduate experience.

Applications, quoting the names of two professional referees and giving brief details of career, should be addressed to the Secretary

RUTHERFORD HIGH ENERGY LABORATORY

HARWELL, DIDCOT, BERKS

from whom further details may be obtained

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY LONDON

ST. JOHN STREET, LONDON, E.C.1

DEPARTMENT OF PURE AND APPLIED CHEMISTRY

Applications are invited for Research Studentships available from September, 1961, from those holding or anticipating to have a good honours degree in chemistry, Grad.R.I.C., or Dip.Tech. in chemistry. Research topics will be selected from the following fields: the chemistry and origin of coal tar constituents; low temperature carbonization studies; physico-chemical studies, including electro-chemistry, surface chemistry, and states of aggregation in solution. The work will be suitable for studies leading to a postgraduate degree or equivalent. Each studentship will carry a stipend of £400 to £500, which may be supplemented by fees from teaching.

Applications, giving full details, including the names of referees, should be sent to the Head of the Chemistry Department as soon as possible.

HIGH DUTY ALLOYS LIMITED

RESEARCH DIVISION

SLOUGH, BUCKS

Physicist or Physical Metallurgist required for fundamental research on the phenomena associated with fatigue and creep of light alloys. Candidates should have an honours degree and preferably some experience of university research and be under 30 years of age. The work will be in a modern and very well equipped laboratory and encouragement is given for the publication of results. A generous salary, depending on qualifications and experience, is available and there is also a pension scheme in operation.

All applications will be treated in the strictest confidence. Please write, giving full details, to the Chief Personnel Officer, at the above address.

BRITISH TRANSPORT COMMISSION

OPERATIONAL RESEARCH UNIT

Applications are invited for the following posts at London Headquarters:

ASSISTANT DIRECTOR. Commencing salary not less than £2,250 per annum. To assist in managing a growing Operational Research Unit including the deployment of research groups, arrangement for outside research contracts, and training and recruitment. Good qualifications and experience are essential with evidence of management ability and leadership.

TWO LEADERS FOR RESEARCH GROUPS which are being built up to study problems concerning movement of traffic and optimum size of transport units. They should be well qualified academically and with considerable experience in application of operational research.

Opportunities also exist for graduates who wish to gain experience of operational research in practice in these groups, and later to assume individual responsibility for investigations.

The senior posts carry a salary up to £2,250 per annum, the others between £780 and £1,290 per annum.

Superannuation scheme. Certain travel facilities. Medical examination.

Write, stating post desired, age, qualifications and experience, to **Director of Establishment (Dept. N), British Transport Commission, 222 Marylebone Road, N.W.1, within 14 days.**

AUSTRALIA

UNIVERSITY OF NEW SOUTH WALES

The University wishes to appoint Senior Lecturers and Lecturers in the following Faculty:

FACULTY OF SCIENCE

Applied psychology (psychometrics and experimental psychology). Botany. Mathematics. Physics.

Salary: Senior Lecturer, £A.2,586 range £A.3,036 per annum; Lecturer, £A.1,766 range £A.2,471 per annum. Commencing salary is determined by qualifications and experience. Subject to passing medical examination appointees will be eligible to contribute to the State Superannuation Fund. First-class ship fares to Sydney of appointees and family will be paid.

Four copies of applications, including the names of two referees, should be lodged with the Agent-General for New South Wales, 56-57 Strand, London, W.C.2, England, and a copy forwarded to the Appointments Section, The University of New South Wales, Box 1, Post Office, Kensington, N.S.W., Marked SA1.

UNITED KINGDOM TECHNICAL ASSISTANCE

The Commonwealth Relations Office invites applications for the post of Pharmacologist at the North Regional Laboratories in Peshawar, Pakistan. The duties of the pharmacologist will be mainly the setting up of a pharmacological section dealing with drugs derived from medicinal plants and the training of laboratory staff. Salary: £3,000 per annum (subject to U.K. income tax) plus tax free oversea allowance of £1,900 per annum (married man) or £1,125 per annum (single man) and additional allowances for children. Free furnished accommodation or refund of 45 per cent of basic hotel bills. U.K. superannuation position will be preserved during tour of duty. All emoluments paid by U.K. Government.

For further information and application form write to Ministry of Labour (E.9), 26-28 King Street, London, S.W.1, quoting PAK/704.

THE CARBORUNDUM COMPANY LIMITED

requires a

QUALITY CONTROL STATISTICIAN

in its Technical Branch at Trafford Park, Manchester

The duties will include devising and introducing statistical methods in the various manufacturing Divisions of the Company. A degree in mathematics and/or good qualifications in statistics are essential. Practical experience in the application of statistical control methods would be an advantage.

All applications, which will be treated in strict confidence, should include details of age, qualifications and experience (if any) and addressed to :

The Personnel Officer,
The Carborundum Company Limited,
Trafford Park, Manchester 17

IMPERIAL CHEMICAL INDUSTRIES LIMITED, DYESTUFFS DIVISION,

has a vacancy in their Research Department at Manchester for an

HONOURS GRADUATE IN MATHEMATICS

to increase the mathematical effort applied to the Division's problems.

The Dyestuffs Division's interests are the most varied of all those in the Company. It manufactures over 6,000 different chemical products which include, besides several kindred dyestuffs, nylon, rubber chemicals, textile auxiliaries, polyurethanes and other polymers. Current research is designed to extend the fundamental understanding of the physical and chemical factors which produce the many different technical effects, as well as into analysis, from a mathematical angle, of the processes themselves. Investigations are in progress into such different topics as theoretical physics, quantum chemistry, polymerization kinetics, and the theory of elasticity. The post offers scope for a wide range of interests and there are excellent prospects of promotion.

The Company operates a five-day, 37½-hour week, a Pension Fund, and an Employees' Profit Sharing Scheme. Assistance can be given towards housing and removal expenses.

Applicants should quote reference L93. Forms may be obtained from the Staff Manager, Hexagon House, Blackley, Manchester 9.

THE BRITISH SHIPBUILDING RESEARCH Association invites applications for Abstractors (male or female). The duties will consist mainly of abstracting and summarizing technical and scientific papers in shipbuilding, marine engineering, naval architecture, general physics and engineering, and also dealing with technical inquiries relating to published material in this field. A degree or equivalent qualification in engineering or naval architecture is desirable, but persons without degrees suitably qualified otherwise will also be considered. A reading knowledge of one or more of the following languages is desirable: German, French, Dutch, Russian, Scandinavian languages. The commencing salaries will depend on age and qualifications. Superannuation under F.S.S.U.—Please apply, giving full details of career and qualifications, to B.S.R.A., Prince Consort House, 27–29 Albert Embankment, London, S.E.1.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING
(UNIVERSITY OF READING)

A temporary post for one year will be available from July in the Physiology Department for a recent graduate in physiology or zoology to assist with research on the bioassay of hormones in blood.

Apply, quoting ref. 61/11, to Secretary, N.I.R.D., Shinfield, Berks.

EXPERIENCED CHEMIST / METALLURGIST who wants to help prepare highly technical literature in the west of London area, even though not greatly experienced in this field, is invited to apply below. The position is permanent. Salary will be according to qualifications and experience. —Box No. 970, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY
(Faculty of Technology in the University of Manchester)

Applications are invited, preferably from organic chemists with Ph.D., for appointment as Research Fellow in the College of Science and Technology (Department of Chemistry) in connection with the development of organic dye filters which will be used for nebular and cometary night-sky photography for astronomical purposes. Earlier work in this direction has resulted in improved filters for photochemical and spectroscopic purposes and for the H_α emission line for astronomical photography. The investigation is expected to extend over two years under the direction of Dr. A. R. Thompson, Lecturer in Colouring Matters in the University and in the College. Candidates should have research experience in organic chemistry; experience in either ultra-violet spectroscopy or dyeing of textile materials would be an advantage. Stipend of £1,000 per annum with F.S.S.U.

Regulations and forms of application may be obtained from the Registrar, the Manchester College of Science and Technology, Manchester 1. Last date for the receipt of applications is July 8, 1961.

UNIVERSITY COLLEGE OF THE WEST INDIES

Applications are invited for (a) Lectureship or (b) Assistant Lectureship in Mathematics. Candidates should possess qualifications in Mathematical Analysis and/or Statistics. Salary scales: (a) £1,050 by £50 to £1,400 by £75 to £1,850 per annum; (b) £800 by £50 to £950 per annum plus local allowance of £250 per annum (pensionable). Entry according to qualifications and experience but in case of Assistant Lecturers and Lecturers below merit bar consideration is given to age in fixing salary. F.S.S.U. Child allowance. Unfurnished accommodation at rental of 10 per cent of basic salary. Up to five full passages on appointment, normal termination and triennial study leave.

Detailed applications (six copies), naming three referees by July 17, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

DOUNREAY FELLOWSHIP IN RADIATION CHEMISTRY

A vacancy exists in the Chemistry Research Group at the Dounreay Experimental Reactor Establishment for a Scientist to take up a Fellowship to undertake fundamental studies in the field of radiation chemistry. The selected candidate will have considerable freedom in the selection of the field of work and in the formulation of the programme with the proviso that the selected topic will be associated with the work of the Group in such a way that it will provide fundamental information on some of the Group's problems. These cover a variety of topics such as the effect of ionizing radiations on the valency changes of vanadium, chromium, cerium and other ions in aqueous solutions, the radiolysis of aqueous solutions of plutonium in acidic media, and the irradiation-induced degradation of liquid hydrocarbons. The irradiation facilities available for this work consist of a kilocurie source of cobalt-60, several strontium-90 sources and a thermal neutron source in the Dounreay Materials Testing Reactor. Normal physicochemical equipment such as an Argon Gas Chromatographic Unit and an ultra-violet spectrophotometer is available in the group and a double beam infra-red spectrometer and mass spectrometer is available in the Analytical Group of the Laboratories.

Applicants for a Research Fellowship, who should be British subjects, should have at least two years postgraduate research experience and preferably hold the degree of Doctor of Philosophy; they will be expected to show evidence of a high standard of research ability, and experience is desirable in the field of radiation chemistry, photochemistry or reaction kinetics.

The Fellowship will be tenable for three years on the expiry of which the holder will be considered for a permanent post at the Establishment.

The value of each award will be assessed according to the individual merit of the candidate selected, within the range £875 to £1,775 per annum. All awards will carry benefits under either F.S.S.U. or the Authority's Principal Superannuation Scheme.

Rented housing available for married officers living beyond daily travelling distance. Hostel accommodation available.

Send postcard for application form to Personnel Manager, U.K.A.E.A., Reactor Group, E.R.E., Dounreay, Thurso, Caithness, quoting reference 254/34.

SUGAR MILLING RESEARCH INSTITUTE

UNIVERSITY OF NATAL, DURBAN

Applications are invited for the post of Assistant Director of the above Institute, which is a national research institute for the Natal Sugar Millers' Association, under the Council for Scientific and Industrial Research research association scheme.

Duties will involve assisting the Director in the Administration and management of the Institute, under a Board of Control, and in directing the Research Programme.

Qualifications required are a higher University degree, either in Engineering, or in Chemical Engineering, or in Chemistry and research experience, including experience of the sugar industry (cane or beet).

A commensurate salary will be determined for a suitable appointee.

Additional information will be supplied on request by the Director of the Institute. Applications, accompanied by the names of two referees, should be sent to the Director to reach him before September 15, 1961, at the address below.

The Director,
Sugar Milling Research Institute,
University Private Bag,
King George V Avenue,
Durban, South Africa.

JENSON & NICHOLSON LIMITED
ROBBIALAC COLORIZER PAINTS

require several

SCIENCE GRADUATES

to join their Production and Research and Development Laboratories at Stratford, London, E.15.

Applications are invited from Graduates who have had experience in the Paint Industry, but applications from Students Graduating this year will be considered.

A good Starting Salary is offered commensurate with qualifications and experience and the posts afford ample opportunity for progress.

Please write, giving full particulars and quoting Ref. A.13, to:

The Personnel Manager,
Jenson & Nicholson Limited,
Jenson House, Carpenters Road,
Stratford, London, E.15

FISONS LIMITED
DEVELOPMENT MANAGER

Fisons have wide interests in the pharmaceutical and chemical fields and require a Development Manager for their pharmaceutical interests in Genatosan Limited, situated in Leicestershire. The Development Manager will be directly responsible to the Managing Director of this Company.

It is expected that suitable candidates will have good qualifications in chemistry, medicine or allied fields. Some experience of the pharmaceutical industry or an interest in pharmaceutical chemistry within the universities or similar institutions is highly desirable.

The successful candidate should be capable of organizing and leading a team of approximately 10 graduates of different disciplines covering both research and development aspects, and will be responsible for producing ethical and proprietary products within the pharmaceutical industry. A considerable degree of originality will be required.

The probable age limits will be 30 to 40. The salary paid will be fully in line with the responsibilities involved.

The Company will be pleased to supply further information to suitable applicants, who should apply with a summary of their careers to the Managing Director (Reference 1), Fisons Limited, Fison House, 95 Wigmore Street, London, W.1.

A SENIOR TECHNICAL ADVISER IS REquired to initiate and develop (with the assistance of a large international organization) an advisory service in animal nutrition with particular reference to vitamins. A good honours degree or professional qualifications in science is essential, and experience in the field very desirable. Age about 30 to 35 years: to cover the whole of the United Kingdom but resident in London. Established personal connections with feed manufacturers and research stations a strong recommendation. Salary according to qualifications and experience. Excellent pension fund. A Junior Assistant is also required.—Apply Box No. 971, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

ELECTRONICS. SENIOR TECHNICIAN with experience in electronics and electrical equipment generally wanted for work in new laboratories of the Department of Mechanical Engineering, Queen Mary College (University of London), Mile End Road, E.1. Placing on salary scale according to experience and qualifications. Scale £690 by £25 to £815 per annum, plus London weighting up to £45 and in some cases plus £30 or £50 special qualification award. Five-day week. Four weeks annual leave. Pension scheme.—Letters only to Registrar (M.S.T.), giving full details of age, experience, present work.

UNIVERSITY OF MELBOURNE
LECTURER IN CIVIL ENGINEERING (HYDRAULICS)

Applications are invited for the above-mentioned position. Experience in teaching, research and in the design and construction of hydraulic works and apparatus are desirable qualifications. The salary range is £A.1,660 to £A.2,360 per annum. Initial salary will be determined according to qualifications and experience. Superannuation similar to F.S.S.U. in Great Britain will be provided.

Conditions of appointment may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on August 4, 1961.

INSTITUTE OF CANCER RESEARCH Royal Cancer Hospital. Research Assistant required in Chester Beatty Research Institute, Fulham Road, S.W.3 (near South Kensington Station) for work on tissue culture in connection with cancer research. Previous experience in tissue culture or bacteriology desirable. Superannuable: salary in region £700 to £860 according to age, qualifications and experience on M.R.C. Technical Officer scales.—Apply with names of two referees to the Secretary, 33 Sumner Place, S.W.7, quoting ref. 301/B/67.

WOOLWICH POLYTECHNIC
LONDON, S.E.18

Principal: Harold Heywood, D.Sc., Ph.D., A.C.G.I., Wh.Sch., M.I.Mech.E., M.I.Chem.E.

Applications invited for two Research Assistantships in the Mathematics Department to work in one of the following fields: hydrodynamics, elasticity, numerical methods and computing. Applicants should possess a first- or second-class honours degree in mathematics and the successful applicants will work for an internal higher degree of the University of London. The Department includes in its equipment a Stantec Zebra digital computer and it is expected that at least one of these posts will be associated in whole or part with work in the field of computing. The posts are tenable for two years, but may be extended and are at a salary of between £550 to £650 per annum which includes six hours teaching or demonstrating. Applicants should indicate the field in which they are interested.

Particulars and application form from the Clerk to the Governors, to be returned by June 30, 1961.

UNIVERSITY OF TORONTO
DEPARTMENT OF MICROBIOLOGY
SCHOOL OF HYGIENE
VACANCIES FOR GRADUATE STUDENTS IN MICROBIOLOGY

Applications are invited from suitably qualified persons to work for M.A. and Ph.D. degrees in Microbiology. Satisfactory completion of course work in Microbiology as an undergraduate is essential. Research interests of the Department include bacterial physiology and morphology, immunology, virology and electron microscopy. Duties will include demonstrating to students. Vacancies exist for the academic year beginning July 1, 1961. Stipends approximately $2,500 per annum.

Applications to be sent to Dr. A. J. Rhodes, Director, School of Hygiene, University of Toronto.

GOVERNMENT OF FEDERATION OF RHODESIA AND NYASALAND

FEDERAL MINISTRY OF AGRICULTURE

VACANCIES:

(1) *Senior Agricultural Economist*
£2,365 per annum fixed.

(2) *Lecturer in Agronomy*—Chibero Agricultural College.
In scale to £735 by £105 to £1,312 10s. by £52 10s. to £1,732 10s.
Entry depending on qualifications and previous experience. Maximum commencing £1,312 10s. per annum.

(3) *Agricultural Chemists*
(a) Soil Survey.
(b) Analytical and Advisory.
In scale £735 to £1,732 10s. per annum as above (2).

Qualifications and Duties

(1) Agricultural Economics Degree, or degree in Economics, Commerce, or similar, with experience in Agricultural Economics and at least eight years' postgraduate experience. Will assist Chief Agricultural Economist.

(2) Degree in Agriculture, preferably Major in Agronomy, and with postgraduate experience in Agronomy. Responsible to Principal, assist Field Husbandry staff farm development lecturers, demonstrations and practical in field Husbandry of three year Diploma in Agriculture for Africans.

(3) University degree, preferably with Major in Chemistry, or Agricultural Chemistry, or equivalent.
Soil Survey—Prepared to spend six months annually in field, often under canvas.
Analytical and Advisory—General analytical (Chemical) duties.

Family passages provided, pensions, medical aid, generous leave, low income tax, excellent schools—free tuition, field allowances, admirable climate.

Application forms and further details from Secretary (R), Rhodesia House, 429 Strand, London, W.C.2.

Closing date: July 6, 1961.

AUSTRALIAN NATIONAL UNIVERSITY

INSTITUTE OF ADVANCED STUDIES
DEPARTMENT OF NUCLEAR PHYSICS

The University proposes to make a number of appointments in the Department of Nuclear Physics (Head of Department: Professor E. W. Titterton, C.M.G., F.A.A.). The posts available are: Readership, not less than £A.3,250; Senior Fellowship, £A.3,000 to £A.3,550; Research Fellowships, £A.1,625 to £A.2,450. The Department is well equipped with a 12 MeV. Tandem electrostatic accelerator, a 2 MeV. Van der Graaf generator, a 1.2 MeV. Cockcroft Walton machine and a 33 MeV. electron synchrotron. Two precision particle spectrometers, a Buechner spectrograph, crystal, solid state, gas and emulsion detectors with associated multichannel recording equipment are available for use with these machines. The main fields of work are in nuclear photodisintegration and its inverse processes and in nuclear structure studies. Superannuation is on the F.S.S.U. pattern. Reasonable travel expenses are paid, and assistance with housing is provided. In addition to the posts referred to above, a number of scholarships are available for men who have completed a M.Sc. degree or who have had outstanding results in their honours B.Sc. examinations. The scholarships are tenable for two or three years and the basic allowance is £A.925 per annum; married scholars with dependent children may be granted an additional allowance of £A.265 per annum in respect of the first child and a further £A.80 per annum for each other child. A contribution towards fares is paid.

Further details are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on July 31, 1961.

UNIVERSITY OF OXFORD

JUNIOR LECTURESHIP IN MATHEMATICS

Applications are invited for a Junior Lectureship in Mathematics. The appointment is for a period of three years from October 1, 1961, or as soon as possible thereafter, and is not renewable. The stipend is on the scale of £900 by £50 to £1,000.

Further details may be obtained from the Secretary of the Mathematical Institute. Applications should be made to Professor E. C. Titchmarsh, Mathematical Institute, 10 Parks Road, Oxford, not later than July 7, 1961.

HEAVY ORGANIC CHEMICALS DIVISION

is expanding its

EXPLORATORY RESEARCH GROUP

to study new tonnage chemicals, to develop *new ways* of making them, to establish the *mechanisms* by which they are formed and to work out the *kinetics* of the reactions involved.

Men and women are needed for this

EXPLORATORY RESEARCH TEAM

Organic chemists and physical chemists are needed most, but we should be glad to have a physicist interested in building novel equipment, a first-class mathematician keen on process development techniques, and chemical engineers anxious to work with chemists.

For further information please write to:

Exploratory Research Group Manager,
Imperial Chemical Industries Limited,
Heavy Organic Chemicals Division,
Billingham-on-Tees, Co. Durham,

quoting reference MB/ER/5.

UNIVERSITY OF MALAYA IN KUALA LUMPUR

DEPARTMENT OF CHEMISTRY

Applications are invited for one post of Lecturer or Assistant Lecturer, depending on qualifications, in the Department of Chemistry. Candidates should have a recognized Honours degree or equivalent qualification and experience in teaching and research. The salary for a Lecturer is £1,148 by £49 to £1,442/£1,540 by £56 to £1,820, and for an Assistant Lecturer £1,001 by £49 to £1,099 per annum. In addition, a variable allowance is at present paid at 35 per cent of basic salary, subject to certain maxima, together with expatriation allowance at specified rates. An allowance is made towards travelling expenses, and housing assistance is available.

Further particulars and application forms should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Kuala Lumpur and London, on July 27, 1961.

UNIVERSITY OF ST. ANDREWS

Applications are invited for an Assistantship in Clinical Chemistry in the Department of Pathology, Queen's College, Dundee, and the Royal Infirmary, Dundee (549 beds). Salary scale: medically qualified, £1,050 by £100 to £1,250 (or £1,350); non-medically qualified, £800 by £50 to £950. Appointment for three years, with possibility of renewal for fourth and final year. F.S.S.U.; family allowance; grant towards furniture removal expenses.

Applications (six copies), containing the names of three referees, to the undernoted, not later than July 8, 1961.

PATRICK CUMMING,
Joint Clerk to the University Court,
Queen's College, Dundee.

AUSTRALIA

INSTITUTE OF CLINICAL PATHOLOGY AND MEDICAL RESEARCH, LIDCOMBE
NEW SOUTH WALES PUBLIC HEALTH DEPARTMENT

GRADUATES IN BIOLOGICAL SCIENCE FOR EMPLOYMENT AS CYTOTECHNOLOGISTS (MALE OR FEMALE)

Commencing salary up to £A.2,290 per annum according to qualifications and experience. Qualifications: Degree in biological science or equivalent. Experience in exfoliative cytology preferable. These posts offer the opportunity for interesting and rewarding work in the field of cancer diagnosis. The Department of Exfoliative Cytology is to be housed in new air-conditioned laboratories at the Institute of Clinical Pathology and Medical Research, Lidcombe. Duties involve the supervision of Scanners engaged in microscopic examination of cells as a means of detecting cancer and also the technical procedures in preparing specimens for examination. Subject to meeting prescribed conditions, appointments are permanent and appointees will be eligible to contribute to the State Superannuation Fund. Liberal recreation and sick leave benefits. Passage to Sydney arranged.

Further particulars and forms of application may be obtained from the office of the Agent-General for N.S.W., 56 Strand, London, W.C.2, with whom applications close on June 25 1961.

OLD ESTABLISHED CHEMICAL MANUfacturers in Midlands have vacancy for qualified Research Chemist with first- or second-class honours degree. Age 28 to 35, preferably with some industrial experience in organic chemicals and synthetic resins. Modern laboratories, five-day week and contributory pensions scheme. Salary according to age and qualifications, £1,200 to £1,800.—Apply, Box No. 972, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

G.C.E. "A" Level School-leavers

If you are intelligent enough to be able to learn modern methods of Steelworks Accounting, Buying or Selling in combination with Metallurgical, Engineering and Production processes, you may wish to be considered for training as a Commercial Apprentice.

Excellent opportunities exist for young men with ability and enthusiasm, and every facility is given for further education with generous financial assistance in addition to normal salary. This includes those who can qualify for a Sandwich Course after a suitable period of works and office training.

Write for further details or an appointment to:

The Education Officer,

GUEST KEEN IRON AND STEEL WORKS

East Moors, Cardiff

GLAXO LABORATORIES LTD

require a

STATISTICIAN

The Company wishes to strengthen its research team by the appointment of an additional statistician with a degree or the A.I.S. qualification. The work of the post will embrace all aspects of research, development and clinical evaluation of new drugs, foods and immunological products, but will not normally involve economic investigations. The post is, therefore, eminently suitable for a young statistician with a strong interest in science who wishes to enter upon a career primarily in the scientific rather than in the economic field.

Similar experience could be helpful but is by no means essential. The starting salary will be related to the age, qualifications and experience of the candidate appointed, which will be progressive. The Company offers first-class general conditions of employment which include a Pension Scheme and the opportunity to participate in the Company's profitability.

Applications should be addressed to the

Personnel Manager,
Glaxo Laboratories Ltd.,
Greenford, Middlesex.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING
(UNIVERSITY OF READING)

Applications are invited from suitably qualified honours graduates for a post in the Bacteriology department. The work will be concerned with the microbiology of the rumen and experience in this field will be an advantage, but is not essential. Appointment in Scientific Officer grade (£717 to £1,222) or Senior Scientific Officer grade (£1,302 to £1,654) according to qualifications and experience; F.S.S.U.

Apply, naming two referees, to Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 61/17.

UNIVERSITY COLLEGE
IBADAN, NIGERIA

Applications are invited for newly-created Chair of Chemical Pathology carrying honorary Consultant-ship to University College Hospital. Salary £3,400 per annum. Appointment to commence as soon as possible. Passages paid for appointee, wife and up to five children under 11 years, on appointment, annual overseas leave and termination. Children's, car and outfit allowances. F.S.S.U. Part-furnished accommodation at rent not exceeding 7.7 per cent of salary.

Detailed applications (twelve copies), naming three referees, by July 3, 1961, to Secretary, Senate Committee on Colleges Overseas in Special Relation, Senate House, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF BIRMINGHAM
DEPARTMENT OF GEOLOGY

Research Assistant required for work upon hydrated silicate melts and glasses. The appointment may be of interest to a graduate in geology, chemistry, or physics and will extend until September 30, 1962, as at present determined. Applications will also be considered from persons of experience and initiative holding a G.C.E. (A level) in two science subjects or other satisfactory qualifications.

Applications, stating age, qualifications and experience, which will determine the salary paid, should reach Professor F. W. Shotton, University of Birmingham, Edgbaston, Birmingham 15, by June 28, 1961. The salary may reach a starting maximum of £650 per annum in the case of appointment in the grade of Senior Technician. An increment of £20 per annum will be payable after one year's service.

PHARMACOLOGIST

Science or medical graduate with research experience in pharmacology or physiology required in the Department of Pharmacology of our Research Laboratories. Ph.D. an advantage. New laboratories in beautiful countryside with easy access to London.

Apply, stating age, qualifications, experience and publications, to the Research Director, Miles Laboratories Ltd., Stoke Court, Stoke Poges, Bucks.

UNIVERSITY OF ADELAIDE

The University invites applications for the following posts, almost all of which are new:

IN THE FACULTY OF SCIENCE

Reader in Applied Mathematics, Senior Lecturer in Mathematical Statistics, and Senior Lecturer or Lecturer in Mathematics; Senior Lecturer in Physics; Lecturer in Organic Chemistry.

AT THE WAITE AGRICULTURAL RESEARCH INSTITUTE

Reader in Protein Chemistry; Senior Lecturer in Electron Microscopy; Lecturer in Physical Chemistry.

Salary scales: Reader, £A2,950 by £A70 to £A3,230; Senior Lecturer, £A2,450 by £A90 to £A2,900; Lecturer, £A1,675 by £A95 to £A2,340; with superannuation on the F.S.S.U. basis. The initial salary may be fixed within the appropriate scale in accordance with the successful candidate's qualifications and experience. Salaries are paid monthly.

FURTHER INFORMATION. (a) The Calendar of the University may be consulted in the Library of any University which is a member of the A.U.B.C. or at the office of the Association. Inside the covers are plans of the University buildings and site and of the Waite Agricultural Institute at Glen Osmond (four miles from the University). (b) A potential candidate for any post should also seek from the Registrar of the University or from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, the following documents: (i) General Conditions of Appointment, which include particulars of tenure, superannuation, removal expenses, invalidity and study leave; (ii) A statement giving further particulars of each post and of such matters as help in housing, conference grants and special support for research. (c) The University will gladly supply any further information desired on request to the Registrar.

Applications, in duplicate, should give the information listed in the final paragraph of the General Conditions of appointment, and should reach the Registrar, the University of Adelaide, Adelaide, South Australia, not later than July 17, 1961.

FISHERIES RESEARCH BOARD OF CANADA

HALIFAX, N.S.

ANALYTICAL CHEMIST—OCEANOGRAPHY

A vacancy exists for an analytical chemist to undertake a programme of research on geochemical and biochemical processes occurring at the sediment-water interface including analyses of major and minor chemical constituents, oxidation-reduction reactions and other related chemical and biochemical phenomena. The duties will include field work at sea, aboard oceanographic vessels.

Applicants should have a Ph.D. degree or equivalent with special qualifications in analytical chemistry and a good background in physical chemistry and biochemistry. Salary will be in the range $6,450 to $7,950 per annum according to qualifications and experience. Superannuation and other benefits of Canadian Public Service apply.

Further particulars may be obtained from the Oceanographer-in-charge, Atlantic Oceanographic Group, 5 Terminal Road, Halifax, Canada.

PILKINGTON BROTHERS LIMITED

require an

ELECTRICAL ENGINEER

to take charge of the High Voltage Laboratory comprising power frequency and impulse test sections with test voltages of up to 1,300 kV. and 2,000 kV. respectively. An intensive programme of research and development relating to toughened glass power line insulators is in progress.

Applications, stating age, qualifications, experience and present salary, should be addressed to the Personnel Officer (Graduate Recruitment), Pilkington Brothers Limited, St. Helens, Lancashire.

NEW ZEALAND NATIONAL RESEARCH FELLOWSHIP

Applications are invited for a National Research Fellowship to be taken up in New Zealand in 1962. Applicants must be British subjects who have graduated at a United Kingdom University. Preference will be given to applicants who are not older than 30 years, who have had not less than two years' research experience (exclusive of that directed to obtaining their degrees) and who have demonstrated their research ability by written work. Copies of written papers should be submitted with applications. The Fellowship is awarded to enable the holder to carry out independent research in any branch of science within New Zealand. It is tenable for one year initially but may be extended by a further year. The Fellowship is worth £985 a year, plus an allowance of £100 a year to a married Fellow. These amounts are tax free. In addition return fares by surface transport (tourist class) are payable for the Fellow but not for his family. The sum of up to £100 a year is also payable to help cover the cost of fees, books, apparatus and travel within New Zealand on research work; or alternatively all fees (excluding examination fees) are payable plus up to £50 a year for books, apparatus and travel. The maximum total sum payable in two years is approximately £2,700. These amounts are expressed in New Zealand currency (£N.Z.1 approximately equals £1 sterling). Candidates should support their applications with at least two testimonials of qualifications and ability, or alternatively arrange for confidential testimonials to be sent direct to the New Zealand Senior Scientific Liaison Officer in London. Applicants should enclose a recent photograph with their applications.

Further information, including copies of the Fellowship regulations, and application forms may be obtained from the New Zealand Senior Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2, with whom applications close on September 30, 1961. Candidates will be told of the results of their applications in January, 1962.

THE COLONIAL SUGAR REFINING COMPANY LTD.

Invites applications for the position of

INORGANIC RESEARCH CHEMIST

In the Company's Research Department, Sydney, Australia

DUTIES: The successful applicant will be required to investigate the chemistry and physical properties of minerals and inorganic substances. Experience in X-ray crystallography or in solid state reactions would be an advantage.

QUALIFICATIONS: Candidates for the above position should have at least an Honours degree in Chemistry, preferably with several years research experience.

SALARY: Commencing salary within the range of £A1,600 to £A2,500 per annum, commensurate with qualifications and experience.

CONDITIONS: The successful applicant will become eligible to join the Company's Employees' Provident Fund after a probationary period and would be eligible to participate in the Company's House Advance Scheme.

First class fares to Sydney, Australia, will be provided for the successful applicant and family, together with an amount of £200 for transport of effects.

Applications, in writing, quoting RD/13 and enclosing copies of references, should be sent to the Company's representative in Great Britain.

Mr. L. F. Mallam,
C.S.R.C.L.
Plantation House, Mincing Lane, London, E.C.3.

UNIVERSITY OF CAPE TOWN

CHAIR OF CHEMISTRY

Applications are invited from physical and from inorganic chemists for the Chair of Chemistry to be filled from January 1, 1962. The salary scale is R.4,600 by R.200 to R.5,400 (£2,300 by £100 to £2,700) per annum.

Applicants should state their age, experience and qualifications, publications and research work, and should give the names of two referees whom the University may consult. Two copies of the application and testimonials should reach the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (from whom memoranda giving the general conditions of appointment, including transport expenses on appointment, and information on the work of the department may be obtained), not later than July 30, 1961. An additional copy should be sent direct by airmail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa, to reach him by the same date. The University reserves the right to appoint a person other than one of the applicants or to make no appointment.

UNIVERSITY OF TASMANIA

LECTURESHIPS OR SENIOR LECTURESHIPS IN CIVIL ENGINEERING (TWO POSITIONS)

The University invites applications for two vacancies in the Department of Civil Engineering. One of the Lecturers will be able to choose his own special field of interest in addition to taking part in the general teaching of the Department. The second Lecturer will be required to give courses in Fluid Dynamics and Turbomachinery. A vortex tunnel owned by the Aeronautical Research Laboratories of the Commonwealth Department of Supply is installed at the University for the purposes of basic research into compressor-blading design. The Lecturer will be required to supervise this research in co-operation with officers of the Aeronautical Research Laboratories. The salary grades for Lecturers are Grade II, £A.1,610 by £A.70 to £A.1,860, Grade I, £A.1,860 by £A.70 to £A.2,350, and for Senior Lecturers, £A.2,450 by £A.70 to £A.2,870. Appointment will be offered within these grades according to qualifications and experience.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on July 31, 1961.

BIRMINGHAM TAME AND REA DISTRICT DRAINAGE BOARD

CHIEF ASSISTANT CHEMIST

Applications are invited for the post of Chief Assistant Chemist which will become vacant in January, 1962, at a salary in Grade C (£1,560 by £70 (3) by £55 to £1,825 per annum) of the Joint Negotiating Committee for Chief Officers, Deputies and other Senior Officers. This appointment is on the staff of the Engineer to the Board, Rookery Park, Erdington, Birmingham. Applicants should preferably be between 30 and 45 years of age. Corporate Members of the Royal Institute of Chemistry and/or hold an honours degree in chemistry. Candidates should have good experience in either analytical, physical, industrial chemistry, chemical engineering applied to biochemistry, or in biochemical processes, and should be able to lead laboratory staff engaged in analytical and research work concerned with sewage and trade waste purification. Experience in sewage purification will be advantageous but not essential. Publication of the results of research work will be encouraged. The appointment will be subject to the provisions of the Local Government Superannuation Acts, to the passing of a medical examination, and to three months' notice on either side.

Applications, stating date of birth, marital state, qualifications, full particulars of present appointment, previous appointments, experience and the names and addresses of three referees, must reach the undersigned not later than first post on Monday, August 21, 1961.

ARTHUR J. WRIGHT,
Clerk to the Board.

Clerk's Office,
Lombard House,
Great Charles Street, Birmingham 3.

ST. THOMAS'S HOSPITAL MEDICAL SCHOOL

Applications are invited for the post of Assistant Lecturer in the Department of Biochemistry. The post will be tenable from October 1, 1961. Commencing salary according to qualifications and experience, in the scale £950 to £1,150 per annum plus London allowance of £60. Membership of the F.S.S.U. and children's allowance scheme.

Applications, giving details of qualifications and the names of two referees, should be submitted by July 1, 1961, to the Dean, St. Thomas's Hospital Medical School, London, S.E.1, from whom further information may be obtained.

ENGLISH ELECTRIC VALVE CO. LTD.

Chelmsford, Essex

The Company has in production high quality germanium and silicon power rectifiers in ratings up to 20 amps.

Improvement in the processes involved in the manufacture of these devices continues in order to increase their reliability in service.

The Company wishes to engage a senior production-development engineer to accept responsibility in the development and production of the rectifiers in current demand, and other devices that the Company wish to market after development.

A substantial salary will be paid to an engineer or physicist possessing sound experience in the semi-conductor field and post-graduate qualifications. Preferred age range 28 to 40.

Applications outlining experience and qualifications should be sent to: Group Personnel Services, English Electric House, Strand, London, W.C.2. Please quote reference N.1594.K.

Botanist
experienced in Weed Research

MAY & BAKER LTD.
Dagenham
Essex

There is an interesting vacancy for an experienced Research Botanist aged 25–35 at the Company's Horticultural/Agricultural Research Station, Ongar, Essex.

The successful candidate will be required to take charge of a team engaged in the screening and development of new herbicides. Candidates should have a good honours degree and at least three years' research experience in weed research or related fields. There is a Pension Fund and Life Assurance Scheme in operation. Five-day week and canteen facilities. Apply initially, in writing, to the Personnel Officer, giving full particulars of qualifications and experience, quoting Reference No. N/164/60.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING
(UNIVERSITY OF READING)

Applications are invited for the following posts, tenable for five years from October 1, 1961, under a grant from the United States National Institutes of Health, for work on the flow and the coagulation of blood. 1. Principal Scientific Officer, with training in physiology and/or biochemistry, and preferably also in Physics. Experience in work on blood an advantage. Salary within range £1,666 to £2,418; F.S.S.U. 2. Assistant Experimental Officer preferably with pass degree or equivalent and experience in biological work. Salary range £450 10s. to £983.

Further particulars from the Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 61/18 for post 1 or 61/19 for post 2.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING
(UNIVERSITY OF READING)

Chemist or Biochemist with first- or second-class honours degree required to join a small team working in the Radiobiochemistry Department under a contract with the International Atomic Energy Agency. The work is on the metabolism of fat in the ruminant and in particular involves a study of the biochemical forms of radioactivity in blood, milk and various organs after the administration of labelled lipids. Experience in radioisotope techniques an advantage but not essential. Salary in scale £717 to £1,222 or £1,302 to £1,654, according to qualifications and experience.

Apply to Secretary, N.I.R.D., Shinfield, quoting ref. 61/20.

UNIVERSITY OF AUCKLAND
NEW ZEALAND
CHAIR OF MICROBIOLOGY

The Council has decided to establish a Chair of Microbiology within the University. Initially, the Professor will be required to take charge of the undergraduate teaching in Microbiology, which forms part of the existing courses in Botany and Zoology. In addition, the Professor will be responsible for the supervision of M.Sc. and Ph.D. students specializing in Microbiology. Separate accommodation for such graduate research will be available from the outset and will form the nucleus of an independent Department of Microbiology which the Council desires to establish. As soon as circumstances permit, the teaching of the Department will be extended to include Microbiology II and Microbiology III as second and third year undergraduate subjects for the B.Sc. degree. It is possible also that the Department will ultimately become responsible for the provision of courses in microbiology for medical students. The salary attaching to the position is £2,800 per annum. Approved surface fares to Auckland will be allowed for the appointee, and his family, plus baggage and settling-in allowance within specified limits.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in New Zealand and London, on July 15, 1961.

AUSTRALIA
THE UNIVERSITY OF NEW SOUTH WALES
TEACHING FELLOW
SCHOOL OF APPLIED PSYCHOLOGY

The School of Applied Psychology at the University of New South Wales has an academic staff of sixteen, headed by the Professor of Applied Psychology, Professor J. F. Clark. The School prepares students taking psychology at pass and honours levels in the Faculties of Arts, Science, and Commerce. Psychology is also taught to students in the Faculties of Medicine, Applied Science, and Engineering. Research is undertaken in the fields of physiological psychology, perception, personality, psychometrics, clinical and industrial psychology, social psychology and counselling; and there are excellent facilities for candidates for higher degrees. The appointed Teaching Fellow will enrol for a higher degree and will carry out some teaching duties. Applicants should have a degree with honours in psychology or equivalent qualifications, and preferably special knowledge of statistics, experimental, clinical, or applied psychology. Salary: £A.1,142 rising £A.1,362 per annum. Commencing salary is determined by qualifications and experience. Initial appointment is for one year, but there are prospects of renewal for a second or third year. Passage to Sydney arranged.

Four copies of applications, including the names of two referees, should be lodged with the Agent-General for New South Wales, 56-57 Strand, London, W.C.2, and a copy forwarded to the Appointments Section, the University of New South Wales, Box 1, Post Office, Kensington, by airmail to reach there before August 4, 1961.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Lecturer in Engineering (Mechanical). Preference will be given to candidates with a major interest in applied mechanics, especially theory of machines, stress analysis and properties of materials, or applied thermodynamics. An interest in mechanical design would be an advantage. University regulations permit teaching staff to read for the degree of M.Sc. and Ph.D. The salary scale £1,050 to £1,850 per annum. Membership of F.S.S.U. and children's allowance scheme. Initial salary according to qualifications and experience.

Applications should be sent not later than July 8, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained. Applications by airmail letter, in the first instance, will be considered from overseas candidates.

PLANT PHYSIOLOGIST WITH STRONG leanings towards, and preferably experience, in plant biochemistry, or biochemist, to join a team of plant physiologists studying the growth and cropping of fruit trees. Adequate knowledge of the fundamentals of biological chemistry and post-graduate experience essential: under 35; salary according to age and experience in Scientific or Senior Scientific Officer grade; F.S.S.U.; appointment on or after September 1.—Full details and forms of application may be obtained from the Secretary, East Malling Research Station, East Malling, Maidstone, Kent, to whom they should be returned not later than August 1.

UNIVERSITY OF ADELAIDE

Applications are invited for appointment as Senior Technical Assistant (male) to take charge of the University's Central Animal House which is situated at the Waite Agricultural Research Institute. An applicant should have had considerable experience in the handling and breeding of small animals required for experimental and teaching purposes. Salary range: £A.1,335 by £A.35 to £A.1,580 with superannuation on F.S.S.U. basis. If the successful candidate comes from the United Kingdom, the University will nominate him (and his family) for assisted passages to Adelaide under the Commonwealth Migration Scheme. If he comes from within Australia or from New Zealand he will be granted equivalent assistance (not exceeding £A.25). Further particulars will be supplied on request to the Registrar.

Applications, giving particulars of age, qualifications, experience and marital status, and including a medical certificate of health and the names and addresses of two referees of whom inquiries may be made, should reach the Registrar, the University of Adelaide, Adelaide, South Australia, not later than July 17, 1961.

QUEEN MARY COLLEGE

(UNIVERSITY OF LONDON)

Applications are invited for two Lectureships in Electrical Engineering. One post is for an engineer or physicist with experience of laboratory techniques associated with research on dielectrics and semiconductors who will be concerned with the development of a newly completed materials laboratory. The other is for an engineer or mathematician with experience in the design of control systems or the use of digital computers in engineering analysis to join a systems engineering group with good facilities for digital computation. Salary scale £1,050 by £50 to £1,400 by £75 to £1,550 (efficiency bar) by £75 to £1,850, plus London allowance of £60. Tenable from October 1, 1961. Initial salary according to qualifications and experience, with F.S.S.U. participation and family allowance of £50 for each child.

Application forms, obtainable from the Registrar, Queen Mary College, Mile End Road, E.1, to be returned by June 26, 1961.

SOUTHERN UNIVERSITIES NUCLEAR INSTITUTE

(Under the auspices of the Universities of Cape Town and Stellenbosch, Republic of South Africa)

Applications are invited for the post of Chief Scientist of the above Institute which will be built round a 5.5 MeV. Van de Graaff accelerator. The Chief Scientist must be an Experimental Nuclear Physicist and will be in control of the Institute. He will be responsible for carrying out the research programme drawn up by a Research Advisory Committee, of which he will be a member. He will be expected, not only to co-ordinate research by members of the participating Universities of Cape Town and Stellenbosch, but also to initiate research himself. Fixed salary: R.5,500 (£2,750).

Applications, stating earliest date on which duties can be assumed, qualifications, at least two references, experience, present salary, and accompanied by a recent medical certificate must reach the Secretary, Southern Universities Nuclear Institute, c/o Merensky Institute for Physics, University of Stellenbosch, South Africa, by June 30, 1961. Further particulars, including membership of pension scheme, are available from the Secretary.

UNIVERSITY OF SOUTHAMPTON

Research Assistant (Biologist or Chemist) required to assist in research on the tank culture of bivalve shellfish at Poole, Dorset; the project under the supervision of the Professor of Zoology, University of Southampton. Applicant to commence not later than August 1, 1961.

Particulars may be obtained from the Secretary and Registrar, University of Southampton, to whom applications should be sent not later than July 1, 1961.

FOURAH BAY COLLEGE

UNIVERSITY COLLEGE OF SIERRA LEONE

Applications are invited for Chair of Geography. Salary £2,500 per annum. Negotiations in progress for salary revision. F.S.S.U. Outfit and family allowances (maximum £300). Passages on appointment, annual leave and normal termination. Part-furnished accommodation at reasonable rent.

Detailed applications (eight copies), naming three referees, by July 31, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY

ST. JOHN STREET, LONDON, E.C.1

ASSISTANT LECTURER

Applications are invited from scientists or engineers with an interest in basic or applied measurements and/or automatic control for the post of Assistant Lecturer in the Department of Production Technology and Control Engineering. The Department is engaged in teaching measurements and automatic control at Diploma of Technology and postgraduate level. Applicants should have an honours degree or a Diploma in Technology. There are facilities for research and study for higher qualifications. Salary on Burnham Scale £930 rising to £1,390 depending on qualifications and experience.

Forms and particulars from the Secretary.

FEDERAL GOVERNMENT OF NIGERIA

PRINCIPAL VETERINARY RESEARCH OFFICER

Required by the Veterinary Research Division of the Federal Ministry of Economic Development. Work of the Division consits of Helminthology, Field or Routine Diagnosis, Field Surveys, Drug Trials and Fundamental Research. Well-equipped laboratories for study of Serology of Helminthology Diseases.

Applicant must be a member of the Royal College of Veterinary Surgeons or have qualification recognized by that College, and should have considerable experience in Helminthology of domestic animals and interest in Entomology and Protozoology. Applicant should be not more than 45 years of age.

Appointment on contract for one tour of 12 to 18 months in the first instance with prospect of extension. Salary according to qualifications and experience in the scale £2,532 per annum (including inducement addition) plus a gratuity of £150 per annum on satisfactory completion of service. Free passage for officer and wife. Children's allowance payable when separated. Liberal home leave on full pay. Quarters at low rent. Income tax at low local rate.

Write for application forms and further particulars, stating briefly age, qualifications and experience, to the Recruitment Attaché, Nigeria High Commission, 9 Northumberland Avenue, London, W.C.2, quoting Ref. Z.5/2.

LEEDS REGIONAL HOSPITAL BOARD

REGIONAL PHYSICS UNIT

Hospital Physicist (Principal Grade) required for duties at the Regional Physics Unit with Headquarters at Cookridge Hospital, Leeds. The successful candidate will be expected to take a large measure of responsibility for the clinical work in connection with two cobalt units and a linear accelerator, but opportunities also exist for work on other problems in physics as applied to medicine. Candidates should possess an appropriate honours degree and have had not less than nine years' experience as a Hospital Physicist. Salary: £1,750 by £70 (3) by £80 by £85 to £2,125.

Applications, stating age, qualifications, experience and details of present and previous appointments, together with dates, and the names and addresses of two referees to the Secretary to the Board, Park Parade, Harrogate, by not later than July 1, 1961.

QUEEN ELIZABETH COLLEGE

(UNIVERSITY OF LONDON)

CAMPDEN HILL ROAD, LONDON, W.8

Organic Chemist required in Nutrition Department, in October or earlier, for work on the synthesis of substances of biological interest. Post suitable for recent graduates or undergraduates now taking final examinations. Salary scale £575 by £25 to £750 with initial salary according to qualifications.

Applications, with names of two referees, to the Secretary by June 30.

AUSTRALIAN INSTITUTE OF NUCLEAR SCIENCE AND ENGINEERING

POSTDOCTORAL FELLOWSHIPS

A small number of Postdoctoral Fellowships may be awarded by the Institute to persons holding the degree of Doctor of Philosophy or equivalent who wish to undertake research projects within the fields of nuclear science and engineering. Fellowships may be held directly with the Institute at Lucas Heights, near Sydney, N.S.W., or at any Australian University, preference being given to candidates whose projects require the use of facilities at the Research Establishment of the Australian Atomic Energy Commission, Lucas Heights. Initial tenure is two years, commencing normally from the date the Fellow begins ful-time work on his project in Australia, and extension for a third year may be granted. Emolument will not be less than £A.1,750 per annum, and funds for equipment and other expenses may be provided. Under certain conditions, the Institute may pay sea fares for a candidate residing overseas at the time of accepting a Fellowship.

Nominations by Australian Universities, or direct applications, as appropriate, will be received by the Institute at any time. Inquiries should be addressed to the undersigned, at the Australian Institute of Nuclear Science and Engineering, Private Mail Bag, Post Office, Sutherland, N.S.W., Australia.

E. A. PALMER,
Scientific Secretary.

AGRICULTURAL DEVELOPMENT OFFICER

required by Aden Government to assume responsibility for an agricultural development area. Appointment on contract for one tour of 18/24 months in first instance. Commencing salary according to qualifications and experience in scale (including Pay Differential) £1,040 rising to £1,844 a year with supplement of £96/£144 a year if officer has dependent children under 18. Gratuity 12½ per cent of total salary drawn with additional payment in lieu of terminal leave. Outfit allowance £60. Free passages for officer and wife. Generous assistance towards children's passages and education allowances up to £288 annually. Candidates should be between 25 and 45 and must have considerable experience in arid/tropical agriculture based on well and flood irrigation. A diploma in agriculture and knowledge of Arabic also desirable.

Apply to Crown Agents, 4 Millbank, London, S.W.1, for application form and further particulars, stating age, name, brief details of qualifications and experience and quoting reference M3A/53503/NF.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

EDITORIAL DEPARTMENT

Two Assistants are required in the Institute and Society's Editorial Department at Lowther Gardens. (a) Senior Assistant with physics and/or mathematics to degree standard and some secretarial experience. Work will include preparation of material for publication, correspondence in connection with publications, a small amount of committee work and responsibility for the day to day running of the office. Salary £750 to £800 according to qualifications and experience. (b) Editorial Assistant with physics and/or mathematics to degree standard to assist in preparation of material for publication. Ability to type an advantage. Salary £650 to £700 according to qualifications and experience. For both posts meticulous accuracy is essential and some experience in editorial work or knowledge of scientific instruments would be an advantage.

Further details and application forms from the Editor and Deputy Secretary, the Institute of Physics and the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

UNIVERSITY COLLEGE

IBADAN, NIGERIA

Applications are invited for post of Senior Technician in Department of Zoology. Salary scale: £1,050 by £25 to £1,100 (bar) £1,150 by £50 to £1,400 per annum. Passages paid for appointee, wife and up to five children under 11 years, on appointment, overseas leave and termination. Part-furnished accommodation at rent not exceeding 7.7 per cent of salary. Children's, car and outfit allowances. Pension scheme.

Detailed applications (six copies), naming three referees, by July 31, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF MELBOURNE

SENIOR LECTURER IN INDUSTRIAL ENGINEERING

Applications are invited for the above-mentioned position. Applicants should have an engineering degree and knowledge and experience of Industrial or Production Engineering, or a Science or Arts degree with qualifications in statistical methods and operations research. The salary range is £A.2,480 to £A.2,950 per annum. Commencing salary will be fixed according to qualifications and experience. Superannuation similar to F.S.S.U. in Great Britain will be provided.

Conditions of appointment can be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on August 31, 1961. Professor P. L. Henderson, Professor of Mechanical Engineering in the University of Melbourne, will be available in London for discussion with any prospective applicants from July 16 to end of August.

KENT COUNTY COUNCIL

KENT EDUCATION COMMITTEE MEDWAY COLLEGE OF TECHNOLOGY DEPARTMENT OF SCIENCE

Applications are invited from suitably qualified persons for the following additional post. Appointment will date from September 1, 1961. Commencing salary on the appropriate Burnham Technical Scale will depend upon training, previous industrial and/or teaching experience. Assistant Lecturer (Grade B) in Chemistry. Candidates should possess an honours degree or equivalent qualification and be capable of teaching to degree standard in inorganic or physical chemistry. Teaching and industrial or research experience would be an advantage. The successful applicant will be encouraged to undertake research work for which there are good facilities in the department.

Application form and further particulars can be obtained from the Principal, Medway College of Technology, Horsted, Maidstone Road, Chatham, Kent /s.a.e.

UNIVERSITY OF NIGERIA

NSUKKA

Applications are invited for (A) Senior Lectureships and (B) Lectureships in Mathematics. Preference will be given to candidates with interests in pure or applied mathematics, statistics or astronomy. Five vacancies exist within the department and successful appointees will be expected to take up their duties in September, 1961. Salary scales: (A), £2,275 by £75 to £2,575 per annum; (B) £1,200 by £75 to £1,650; £1,725 by £75 to £2,175 per annum. Entry point according to qualifications and experience. Superannuation on basis similar to F.S.S.U. Passages on appointment, leave (three months after each tour of approximately 21 months) and normal termination for applicant, wife and up to five children up to age of 11. Normal contract is three years in first instance. Children's, car, baggage and outfit allowances. Part-furnished accommodation at rent not exceeding 7.7 per cent of salary.

Applications (six copies), naming three referees, by June 22, 1961, to London Representative, University of Nigeria, 33 Craven Terrace, London, W.2, from whom further particulars may be obtained.

UNIVERSITY OF GLASGOW

LECTURESHIP IN COMPUTING LABORATORY

Applications are invited for a Lectureship in the Computing Laboratory, tenable from October 1, 1961. Salary scale: £1,050 to £1,850 per annum, F.S.S.U. and family allowance benefits. The principal equipment of the Laboratory is an English Electric DEUCE computer. Applicants should have experience in the use of digital computers, preferably in applications to crystallography or business calculations.

Applications (eight copies), should be lodged, not later than June 30, 1961, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

ESSEX COUNTY HOSPITAL, COLCHESTER. Applications are invited for the post of Physicist to the Radiotherapy Department (senior grade). Facilities exist for conventional radiotherapy, radium and limited isotope work. A new Department with Tele-Cobalt therapy and more extensive isotope work is to be built shortly. Candidates should preferably have had experience in these fields.—Applications to, Group Secretary, Colchester Group H.M.C., 14 Pope's Lane, Colchester, Essex.

UNIVERSITY OF ABERDEEN

DEPARTMENT OF FORESTRY

Temporary Assistant required in the above Department for an Economic Survey of Private Forestry in Scotland. Graduate in forestry preferred. The work will consist of visits to private estates and the analyses of cost and other data. It may continue for about four years. Commencing salary £650 per annum.

Applications by July 15, 1961, to the Secretary, Department of Forestry, University of Aberdeen, Old Aberdeen, from whom further particulars may be obtained.

UNIVERSITY COLLEGE OF SWANSEA

Applications are invited from suitably qualified candidates for the following posts in the Department of Physics: An Assistant Lectureship. A Lectureship. Salary scales: Lectureship, £1,050 by £50 to £1,400 by £75 to £1,850 per annum; Assistant Lectureship, £800 by £50 to £950 per annum. F.S.S.U. benefits and family allowances.

Further particulars can be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications (six copies), must be received by Saturday, July 1, 1961.

QUAKER OATS LIMITED

require a recently Qualified Graduate in Nutrition or Biochemistry (preferably male) for their Animal Nutrition Department. Age 22/25, starting salary £650 to £750. Applicants should be capable of applying mathematics to problems relating to the nutrient composition of feed ingredients and compounded Animal Feeds. Training will be given in computation technique.

Although the duties will generally be of an office nature they will occasionally incorporate field trials and advisory work.

Full details of age, education and experience, should be sent to:
The Personnel Manager (AW12),
Quaker Oats Ltd.,
Bridge Road, Southall, Middx.

GRADUATE BACTERIOLOGIST REQUIRED to assume charge of Bacteriological Section. Duties include routine bacteriological control, microbiological assay, and participation in research. Five-day week. Staff canteen. Pension scheme.—Write, with particulars of age and experience to Personnel Department, the Crookes Laboratories Limited, Gorst Road, London, N.W.10.

PHYSICISTS (TWO) REQUIRED TO JOIN group responsible for radiation measurements and dosimetry including the development of new instruments and techniques connected with 6 MeV. linear accelerators, teletherapy units and radioactive isotopes, at new hospital near Sutton, Surrey. Appointment in Basic Grade £650 to £1,150 plus London Weighting, initial salary depending on age, qualifications and experience.—Applications, with names of two referees, to House Governor, Royal Marsden Hospital, Fulham Road, S.W.3, as soon as possible.

PLANT PROTECTION LIMITED, A SUBsidiary company of Imperial Chemical Industries Limited, requires a Horticulturist to fill the position of Guide/Demonstrator to its estate at Fernhurst, near Haslemere, Surrey. Applicants should have a good knowledge of Horticulture and preferably some acquaintance with problems involving Pests and Diseases in Crops. Those with a good degree or National Diploma in Horticulture will be preferred.—Applicants should be between 27 and 40 years old and should write, giving brief particulars only, to the Staff Officer, Plant Protection Limited, Fernhurst, near Haslemere, Surrey.

THE LONDON HOSPITAL HAS A VACANCY for an honours graduate in its Physics Department. The appointment will be to the Basic or Senior grade, according to the experience in medical physics of the successful candidate. Routine duties will include clinical problems in radiotherapy, although the Department's interests are not limited to this field. There are good opportunities for exercising initiative in development and research, and technical assistance includes a first-class instrument workshop.—Applications, with the names of two referees, to the House Governor, the London Hospital, Whitechapel, E.1.

AUSTRALIA

THE UNIVERSITY OF NEW SOUTH WALES PROFESSOR OF PURE MATHEMATICS

The University invites applications for appointment to the Foundation Chair of Pure Mathematics in the School of Mathematics. Salary: £A.4,292 per annum. The School, under the headship of Professor G. Bosson, is composed of the Departments of Pure Mathematics (Professor to be appointed), Applied Mathematics (Professor J. M. Blatt), Mathematical Statistics (Associate Professor J. B. Douglas), and Engineering and General Mathematics (Associate Professor A. Keane). The School of Mathematics prepares students taking mathematics at pass and honours level in the Faculties of Arts and Science. In addition, a considerable amount of mathematics is taught to students whose main interests are engineering and applied science. The school operates a well equipped Computing Laboratory and the University also possesses a large electronic digital computer (UTECOM, an English Electric DEUCE machine). After passing a medical examination, the successful applicant will be eligible to join the State Superannuation Scheme, leading to a maximum pension of £A.2,184 per annum. Subject to the consent of the Council of the University, he may undertake a limited amount of higher consultative work. Professors at the University are eligible to apply for six months' study leave, with full salary, after three years of service, or twelve months after six years. With the approval of the University and its bankers, married men may be assisted by loans to purchase a home. The University reserves the right to fill the Chair by invitation. First-class fares to Sydney of appointee and family will be paid.

Further information on the activities of the School and conditions of appointment may be obtained from the Agent-General for New South Wales, 56-57 Strand, London, W.C.2, with whom four copies of applications, including names of three referees should be lodged, and a copy forwarded to the Appointments Section, the University of New South Wales, Box 1, Post Office, Kensington, New South Wales by airmail to reach there before August 14, 1961.

UNIVERSITY COLLEGE HOSPITAL

GOWER STREET, LONDON, W.C.1

DEPARTMENT OF CLINICAL PATHOLOGY

Research Assistant required for the Clinical Bacteriology Laboratory for one year in the first instance. Medical qualification desirable but not essential.

Further particulars from the Administrator and Secretary.

UNIVERSITY OF WESTERN ONTARIO

LONDON, CANADA

Research Associate in radio physics, with M.Sc. or Ph.D., required for one year appointment. Salary commensurate with experience. Research includes instrumentation for study of turbulence in the lower atmosphere.

Applications to Professor D. R. Hay, Department of Physics.

UNIVERSITY OF GLASGOW

RESEARCH FELLOWSHIP IN THE COMPUTING LABORATORY

Applications are invited for the post of Research Fellow in the Computing Laboratory, tenable from October 1, 1961. Applicants should have an honours degree in mathematics or a related subject. Experience in the use of digital computers, although not necessary, would be an advantage. The Fellow will be required to undertake research in mathematical fairing of ship's lines. The salary, depending on qualifications and experience, will be not more than £1,[illegible] per annum.

Applications (three copies), giving the names of not more than three referees, should be lodged, not later than June 30, 1961, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

TECHNICAL ASSISTANT REQUIRED FOR work connected with medical applications of radioactive isotopes and of high energy X-ray equipment, including linear accelerators, at new hospital near Sutton, Surrey. Applicants should possess O.N.C. in Applied Physics, G.C.E. "A" level Physics, or similar qualification. Appointment as (1) Technician-in-Training, salary depending on age, or (2) Technician, maximum age 21, £570 to £710, initial salary dependent on age, qualifications and experience.—Applications, with the names of two referees, to the House Governor, Royal Marsden Hospital, Fulham Road, London, S.W.3, as soon as possible.

INSTITUTE OF CHILD HEALTH
UNIVERSITY OF LONDON

Laboratory Technician required for the Neonatal Unit at the Hammersmith Hospital, Ducane Road, W.12. Biochemical experience an advantage. A.I.M.L.T. or equivalent preferred. Salary, Senior Technician II, Whitley Scales.

Apply to the Secretary, Institute of Child Health, the Hospital for Sick Children, Great Ormond Street, W.C.1, giving age, experience and qualifications.

TRADE ANNOUNCEMENTS

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GRANTS & SCHOLARSHIPS

UNIVERSITY OF MANCHESTER
RESEARCH STUDENTSHIPS IN SCIENCE

Applications are invited for the above studentships, normally tenable for three years and of a value comparable to that of a D.S.I.R. Research Studentship. Candidates must hold the degree of Bachelor or Master of a British University other than Manchester.

Applications should be sent not later than July 1, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

SUNDERLAND EDUCATION AUTHORITY
TECHNICAL COLLEGE

Applications are invited for Research Studentships in Applied Electronics and Automatic Control, Chemistry, Civil Engineering, Geology, Metallurgy, Pharmacy, Pharmacology and Applied Physics. Candidates should hold a good degree or equivalent qualification but undergraduates in their final year will be considered. Appointments will date from September 1, 1961, and will normally be tenable for two years. Successful candidates will be expected to read for higher degrees or Membership of the College of Technologists. The value of the award is £500 per annum but a local firm is prepared to supplement one of the awards by £200 per annum for a candidate specially qualified to work on a problem in Applied Electronics.

Further particulars and forms of application may be obtained from the Registrar, Technical College, Sunderland, Co. Durham. Completed applications should be sent to the undersigned.

W. THOMPSON,
Director of Education.

Education Offices,
15 John Street,
Sunderland, Co. Durham.

MENTAL HEALTH RESEARCH FUND
TRAVELLING FELLOWSHIP ABROAD FOR POSTGRADUATE STUDENTS IN SCIENCES BASIC TO PSYCHIATRY

The Mental Health Research Fund awards annually a Travelling Fellowship open to Non-medical Research Students intending to work in a field relevant to mental illness such as Neurophysiology, Neurochemistry, Pharmacology, Psychology, Sociology, etc. The Fellowship, which is additional to the Fellowship open to medical students, provides travelling expenses and full subsistence in a University or other Department abroad for up to six months. Applicants should generally be in the first five years after taking their B.A. or B.Sc. degree. In support of their applications they should submit an essay (length about 5,000 words) on some topic of their own choosing with clear relevance to research in mental illness. Before writing the essay the candidate should submit his full title to the Secretary for approval, at the address below. The final selection will be made by interview combined with consideration of the candidate's academic record.

Completed essays should be sent in triplicate, together with a brief curriculum vitae, to the Secretary, Research Committee, Mental Health Research Fund, 39 Queen Anne Street, London, W.1 (Telephone WELbeck 1272), before March 1, 1962.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE
RESEARCH STUDENTSHIP IN CHEMISTRY

Applicants for this Studentship should have a good honours degree including chemistry. The successful applicant will be expected to read for a higher degree working on problems related to Cationic Polymerization under Dr. P. H. Plesch. Stipend not less than £400 per annum. Applications from this year's graduands and from chemists in industry or abroad are welcome.

Applicants should send a brief curriculum vitae and names of two referees to the Registrar, the College, Keele, Staffs, England, as soon as possible, and not later than July 8, 1961.

UNIVERSITY OF NOTTINGHAM
POSTGRADUATE AWARDS

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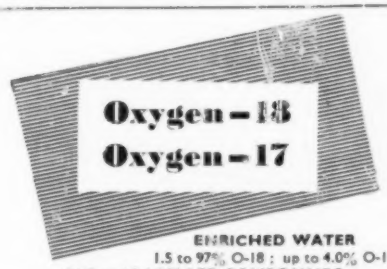

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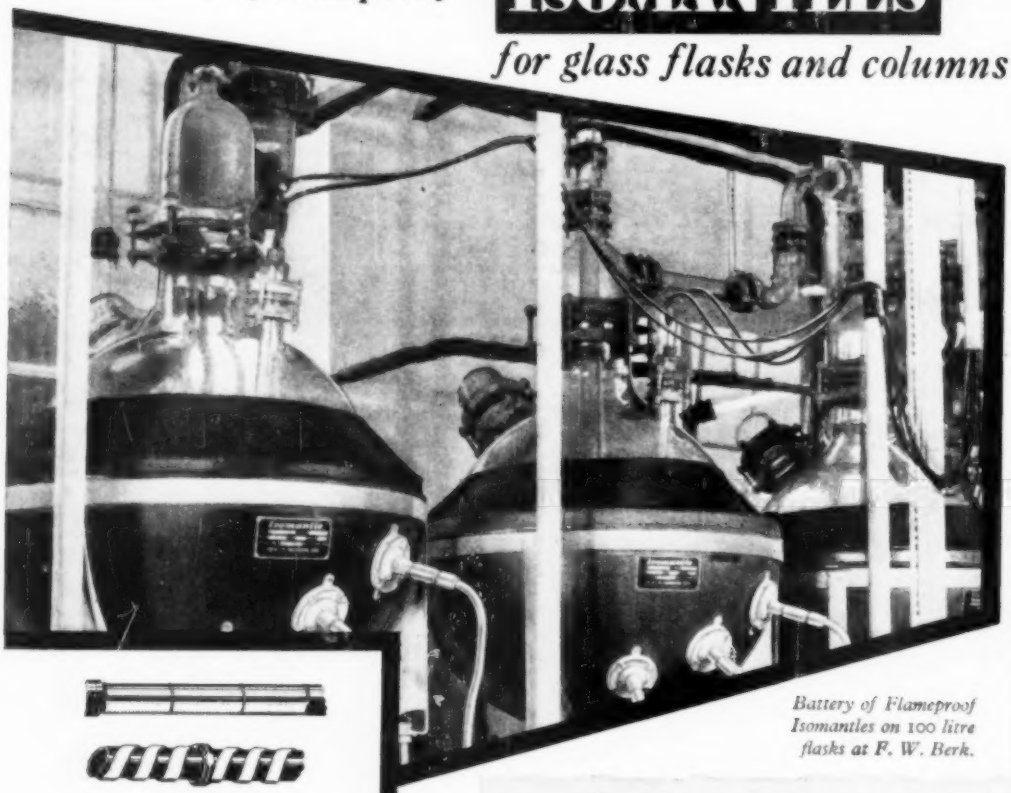

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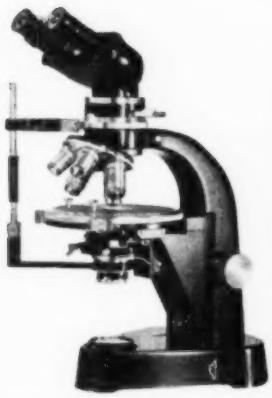

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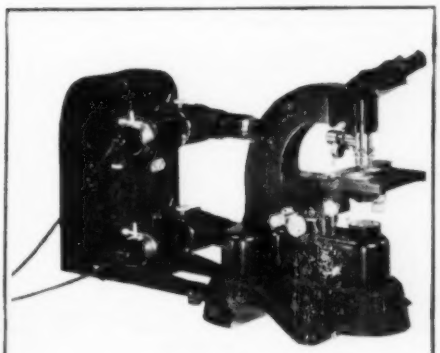

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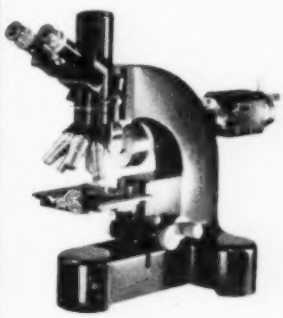

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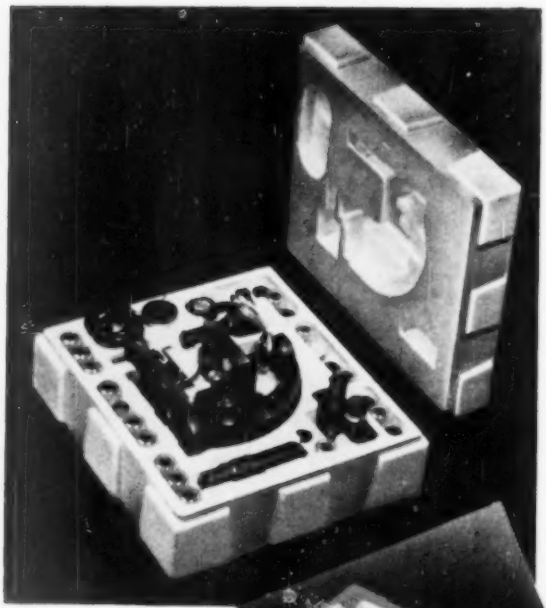

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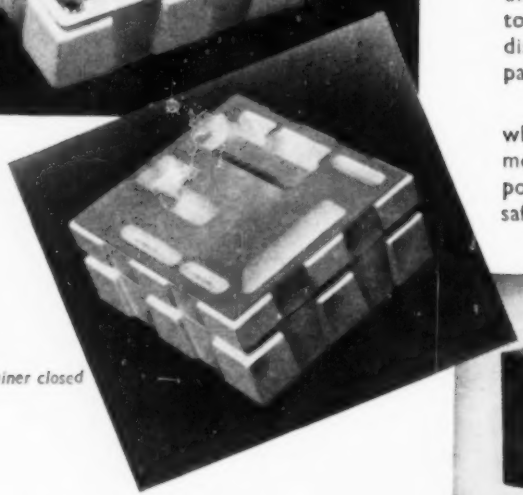

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